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# *The*
# NEWER KNOWLEDGE
# *of*
# HYGIENE *in* DIET

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*by*

J. SIM WALLACE

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*"Prevention is better than Cure"*

This book is primarily dedicated to Medical Officers of Health, to Maternity and Child Welfare workers and to mothers of young children who appreciate the value of good health and facial beauty, as well as the prevention of various other common diseases of the alimentary canal.

# Preface

It is difficult adequately to express my gratitude and thanks to Dr. Paul H. Belding for publishing a resumé of the solution of many disputed questions with regard to the NEWER KNOWLEDGE OF HYGIENE IN DIET in the renowned pages of *Dental Items of Interest,* month after month, almost without intermission from January 1946 to June 1949.

Even yet, however, it is not realized by many physicians how important it is for them to be well acquainted with the subject. As is well known, the problem specially occupying the attention of dentists, doctors and some few scientists is the cause of the *prevalence of dental caries.* To indicate this more fully let me quote from a recent article by Professor Humphrey F. Humphreys, O.B.E., M.C., M.B., Ch.B., M.D.S., F.D.S., R.C.S., England, Honorary Physician to the King, in which he naturally dwells on "the enormous increase in the incidence of the disease in modern times, particularly in the last century amongst the white races. Though an ancient disease, its incidence stamps it as a disease of civilization and one might almost say a disease associated with improved nutrition. Amongst ancient Egyptians it was almost confined to the wealthy classes and in modern times it increases *parip assu* with the successive rise in the standard of living: so that on historical grounds it would appear unlikely to be a deficiency disease, though the case of beriberi shows that this is not impossible. But reflection on the evidence we possess from the social life of the poorer classes in the Middle Ages, a period when dental caries appear to have been uncommon: throughout the winter months they had no fresh meat, no vegetables or fruit, and little if any milk, and in England lived almost entirely on cereals, salted meat and bacon. This is a diet which anyone today would regard as neither balanced nor adequate, and which must have been considerably deficient in vitamins, yet it did not give rise to dental caries. Clearly in accounting for its modern prevalence we have to isolate some factors which operate today but which did not operate some centuries ago. This is our problem." And it may be added that since we know the correlated problems it is a simple matter to solve them all together.

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# Foreword

On account of the interest which has been taken in THE NEWER KNOWLEDGE OF HYGIENE IN DIET and the recognition of its extraordinary importance in the prevention of disease, it seems desirable to give a brief summary of the views of the more important pioneers in the various branches of biology, who have helped directly or indirectly to advance our knowledge with regard to diet and *accessory* foodstuffs, before the word "vitamins" was introduced in 1912 and "struck the imagination of the public." As the first four of my own books are out of print a few excerpts from them will also be introduced where they seem to be apropos to give historical sequence to the subject.

J. S. W.

PUBLISHERS' NOTE: The publishers regretfully announce that the author died on July 13, 1951, at the age of 82.

# Contents

CHAPTER I

Page

Famous Biologists and Their Influence on the Principles of Dietetics ........ 1

*History of Vitamins* ........ 1

*History of Bacteriology* ........ 2

*Lamarck & Darwin* ........ 3

*The Digestive Juices* ........ 4

CHAPTER II

Eminent Biologists, Physiologists, Dietitians and Their Influence on our Knowledge of Alimentary Hygiene...... 7

CHAPTER III

Some Eminent 19th Century Dentists and Their Influence on our Knowledge of Alimentary Hygiene.............. 16

CHAPTER IV

Civilization and Diet in Relation to the Development of Jaws and the Prevention of the Diseases of the Teeth.... 30

CHAPTER V

Observations, Discussions and Progress................ 40

CHAPTER VI

Dental Caries, Discussions and Recent Progress......... 49

CHAPTER VII

Dietetic Theories ........ 63

CHAPTER VIII

Diet, Refinement of Food, Irregularities of the Teeth..... 76

CHAPTER IX

Modern Dietetics in the Causation of Disease........... 90

CHAPTER X Page

Ideas Current From 1900-1910 .......... 97

CHAPTER XI

Author's Experiences—1900-1910 .......... 114

CHAPTER XII

A Review of the Literature from 1911-1920 .......... 121
*Foodstuffs and Dental Caries* .......... 130

CHAPTER XIII

Dental Hygiene in Infancy and Childhood .......... 132

CHAPTER XIV

Excellent Results .......... 138

CHAPTER XV

Statistical Results, Pre-War and Post-War (1914-1920) .. 146
*Food in Wartime* .......... 151
*Prevention of Decay of Teeth* .......... 152

CHAPTER XVI

Inferences from Experiments on Animals .......... 154

CHAPTER XVII

Vitamins, Dental Caries and Sugar .......... 162

CHAPTER XVIII

Discussions and Repercussions 1921-1930 .......... 173

CHAPTER XIX

Progress and Controlled Research .......... 185
*Liable to Induce Dental Caries* .......... 194
*Cleansing and Preventive of Dental Caries* .. 194

CHAPTER XX

Vitamins (Fourth Decade Continued) .......... 200

Page

CHAPTER XXI

Civilization and the Prevalence of Dental Caries—Fourth Decade *(Part 1)* .......... 209

CHAPTER XXII

Fourth Decade Concluded *(Part 2)* .......... 217

CHAPTER XXIII

Medical Dictates and Dental Research (5th Decade, 1941-1948) .......... 238

CHAPTER XXIV

Errors, Omissions, Rules and Results (5th Decade, 1941-1949) .......... 253

# Chapter I

## FAMOUS BIOLOGISTS AND THEIR INFLUENCE ON THE PRINCIPLES OF DIETETICS

The newer knowledge of hygiene in diet may be said to have originated in the discovery that scurvy could be prevented and also cured by including in the diet fresh vegetables and fruits. Thus, referring to this disease we find that "even so long ago as 1734 Bachstrom definitely stated that it could be prevented and rapidly cured when fresh vegetables and fruits were available." [1]

### HISTORY OF VITAMINS

Recently, commenting on the early history of vitamins, Chalmers Watson[2] an eminent Scottish physician, wrote: "In the light of recent work, our first knowledge of vitamins—although the term vitamins was not then applied—was the discovery of the curative influence of fresh foods and vegetables in the treatment of scurvy by Lind in 1757." This great discovery received very tardy recognition. Lind, in his diary, records that traditional beliefs were then as difficult to control as we find them now, for he wrote: "Some persons cannot be brought to believe that a disease so fatal and dreadful can be prevented or cured by such easy means. They would have more faith in some elaborate composition, dignified by the title of an anti-scorbutic golden elixir or the like. It is no easy matter to root up old prejudices, or to overturn opinions, which have acquired an establishment of time, custom and great authorities." [3] However, before 1890 it may fairly be said that widespread recognition had been given to the view that scurvy could be prevented and cured when fresh vegetables and fruits were available. Thus, in the textbook of medicine which I read for my final examination, students were taught that "scurvy is a disorder which primarily depends on a morbid condition of the blood, arising from a deficient supply of certain substances necessary for proper nutrition. . . ." [4] With regard to treatment, the author of this textbook states that "it is important without delay to restore those substances to the system, to the want of which the disease is primarily due. . . . For this purpose, fresh vegetables and green stuff should be freely supplied. Lime or lemon juice . . . is also of great value." [4]

Incidentally, we may here observe that in the same textbook students were taught that in the treatment of rickets, "careful attention to diet, and general hygienic management claim the foremost place both as preventive and curative treatment. . . ." [4] With regard to diet, Dr. Carter says, "starchy foods should be suppressed altogether or restricted in quantity . . . and may be replaced by light nitrogenous food (milk, yolk of egg, etc.)." [4] With regard to drugs, cod liver oil is italicized and holds pride of place.[4] Nevertheless, as even yet it is not clear how the antiscorbutic factor prevents and cures scurvy, or how cod liver oil likewise prevents and cures rickets, and since there are various other questions associated with the role or mode of action of the vitamins which are still obscure, it may be well in the first place to direct attention to relevant aspects in the various branches of biology upon which the newer knowledge of hygiene in diet depends.

For more than a century after the publication of Lind's *Treatise on the Scurvy* in 1757, no particular attention was given to any other disease resulting from a deficiency or *absence* of "organic complexes" or substances which could not be synthesized by the animal body, e.g. cellulose and vitamins. Fortunately, however, great progress was made in various branches of biology upon which much of our knowledge is founded, e.g., bacteriology, zoology, botany, physiology, embryology and developmental anatomy, anthropology, and organic evolution generally. For this and other reasons, a brief historical introduction to some of these branches of science seems desirable to indicate the source and reliability of the facts and observations on which the newer knowledge is based.

## History of Bacteriology

The most important branch of biology with which our theme requires us to deal is bacteriology. This science is recognized to have commenced when in the latter half of the 17th century "the Jesuit Kircher (1601-1680) first wrote of microbes. His magnifying apparatus was very primitive, but he observed what he termed "minute living worms" in decomposing meat; milk and other substances, and suggested that the processes of putrefaction as well as the causation of some diseases were due to these living organisms. In 1683 Leeuwenhock (1632-1723), the Dutch microscopist, communicated to the Royal Society of London a series of observations which he had made on bacteria, using an instrument of his own manufacture. He noted the presence of mobile creatures in an emulsion made from the tartar of teeth. Linnaeus followed him, and in 1762 the Viennese physician Plenciz put forward the theory that each infectious disease was caused by a special living microbe . . . Ehrenberg in 1836, and Cohn in 1875 added other facts to our knowledge, and these observers were followed by Pasteur, who may be regarded as the real founder of modern scientific bacteriology. This great Frenchman (1822-95) proved beyond doubt that processes of fermentation were due to living organisms." [5] Louis "Pasteur was one of the most brilliant investigators of the 19th century. He first attracted notice by his solution of the problem presented by isomerism, which ultimately led him to the discoveries connected with fermentation with which his name is universally associated." [5] Further reference will be made to his teachings when we come to deal with oral and alimentary hygiene.

## LAMARCK & DARWIN

Next let me call attention to another outstanding figure among the first of the famous group of biologists who adorned the 19th century J. B. Lamarck "who was the greatest zoologist of his time, ranking with Linnaeus and Cuvier. With the latters' hypothesis of the sudden creation or extinction of species, however, he strongly disagreed, advocating the gradual descent of all living animals from fossil form. . ." but though his doctrines "are closely allied to those of Darwin, and represented an immense advance on previous thought, he failed to make Darwin's fundamental discovery of natural selection to account for variation." [5]

Darwin's book on the Origin of Species by Natural Selection, or the Struggle for Existence as A. R. Wallace called it, was published in 1859 and the whole edition of 1,250 copies was exhausted on the day of issue and a storm of controversy was aroused.[6] Needless to say, Darwin's contentions gradually became accepted, but one aspect of his theory came to be questioned even by his most enthusiastic admirers. Thus, another controversy was aroused assailing the very foundations of a certain aspect of Darwin's hypotheses "by demanding evidence that the acquired characters upon which they rest are capable of hereditary transmission." [6] Nevertheless, for many years Lamarck's theory of hereditary degeneration from lack of use, and the belief in the biological transmission of acquired characters continued. Thus "in America a school of Neo-Lamarckians appeared and for a time flourished under the inspiration of the vigorous personality of E. D. Cope." [6] Unfortunately this Neo-Lamarckian belief lingered on into the present century, not only in America but also in England and elsewhere.

The foregoing dissertation is not a digression from our present subject, for as Dr. Oran Starr, one of America's highly distinguished thinkers, recognizes in his book entitled *Lamarck-Darwinism and Dental Diseases* "the cause of dental disease is so broadly interwoven with physiological process as directed by law that the beginning of its disentanglement and the beginning of its comprehension, was possible only when such minds were brought to bear upon it, as were soundly equipped with a potent belief in the truth of the evolution of life, and in the practicability of this great system of thought. . . . All dental diseases are produced . . . by imposing environmental conditions upon the individual differing from those which obtained during the evolution of the species." [7]

Whether his generous association of my name with the foregoing sentences is justifiable is not for me to pass on opinion; suffice to say that the doctrine of evolution, which as a student in biology I learned at the University of Glasgow, well nigh sixty years ago, aroused my enthusiasm and forced me to become dubious about many ideas espoused by the medical and dental professions, when a few years later, as a dental student I began to take a special interest in oral and alimentary hygiene. At that time—the last decade of the 19th century—the explanation of the cause or causes of the astounding prevalence of dental caries and the deplorable state of the teeth, even of young children, became a question of extraordinary importance and concern. The only answer that attracted notable attention was the assumption that civilization caused a degeneration in the structure of the teeth. How or why this should or could have resulted from civilization was not at all satisfactorily explained, nor was any rational explanation given for the prevalence of other correlated diseases and disorders, such as developmental deficiencies of the jaws and consequent crowding or derangement in the position of the teeth. And, certainly, no reason was even suggested to induce anyone to believe that microscopic defects in the enamel or the degeneracy of the teeth, together with unhygienic states of the mouth, teeth, gums and alimentary canal, were of any survival value.

## The Digestive Juices

My continued interest in natural selection and evolution led me to reconsult the books on biological subjects which I had read in my student days. By way of introduction, let me refer to Sir Michael Foster's *Textbook of Physiology,"* [8] wherein he devotes a chapter of about 80 pages to the "Tissues and Mechanisms of Digestion," and begins with a section on "the Properties of the Digestive Juices." Among other things he says, no doubt, quite correctly, with regard to the saliva.

"Its reaction in a healthy mouth is alkaline, especially when the secretion is abundant. . . . The chief purpose served by the saliva in digestion is to moisten the food and to assist in mastication and deglutition. In other animals and in man it has a specific solvent action on some of the food-stuffs." [8]

The solvent action is discussed at some length and a chemical equation given indicating the nature of the conversion of insoluble starch into soluble sugars. Thus he notes that "starch $C_6 H_{12} O_5$ or more probably $C_{18} H_{30} O_{15} + 3\, H_2O = \overset{\text{(grape sugar)}}{C_6 H_{12} O_6} + 2\ (\overset{\text{(dextrin)}}{C_6 H_{10} O_5} + 2\, H_2O = 3\ (C_6 H_{12} O_6)$." [8] As the ptyalin in saliva has little or no time during mastication to convert starch into soluble starch and "the dextrins are readily soluble in water," [9] it would appear that the function of the ptyalin is primarily to make the starch readily soluble, and thus easily flushed away by the saliva, especially when the food encourages mastication. Otherwise, starch would be liable to become packed or retained unduly long in the crevices of or between the teeth, particularly if the food is of a sugary nature and liable to undergo a mannitic or gummy fermentation, thus giving rise to the conditions requisite to initiate the formation of lactic acid and foster the progress of dental caries. Unfortunately Foster gives no indication of this function of the ptyalin as an agent in liquefying the starch so as to make it well-nigh inevitable to be flushed away from the teeth by the saliva, and thus ensure a hygienic state of the mouth as far as carbohydrates are concerned, without the aid of a toothbrush, antiseptics, and alkaline mouth washes.

After some fifty pages Foster comes to the "Mechanism of Digestion," saying that "during mastication the food is moved to and fro, and rolled about by the movements of the tongue." [8] Thus lightly and incorrectly did he refer to the process of mastication which, as we shall see later, plays an important role in the physiology of oral hygiene. Under the heading "Deglutition" which follows, Foster says, "The food when sufficiently masticated is, by the movements of the tongue, gathered up into a bolus on the middle of the upper surface of that organ . . . and thrust back between the tongue and the palate through the anterior pillars of the fauces." [8] Here again no indication is given of any idea as to how the mouth and teeth are kept clean, although this may so easily be felt and observed "especially when the secretion is abundant." [8] Nor can we believe that the saliva is poured out during the process of mastication, and for some time thereafter for idle purposes, especially when we bear in mind to what uses its buffer salts, phagocytes and ferments, organized and unorganized, may normally be put.

Were it not that catchwords, clever graphs, misleading advertisements and "feeding experiments illustrating the importance of accessory factors in normal dietaries,"[10] confuse the minds of those who lack the "elementary knowledge of the first principles of digestion," [11] one might be astonished to find that many dietitians overlook even their own feelings during mastication, which show that boluses are not formed as the result of mastication, but that there are physiological processes of such a nature that the teeth and mouth of man (as well as other mammals) are kept in a hygienic state when normal or appropriate detergent food is eaten. It is remarkable how completely recent research has distracted attention from the all important function of the saliva to facilitate the movements of the tongue, lips and cheeks so as to protect the superficial layers of the oral epithelium and the enamel of the teeth, which otherwise might have their power of resisting the invasion of pathological micro-organisms impaired, and permit food debris injuring or disfiguring the exposed surface of the teeth especially in stagnation areas. It is no doubt true to say that saliva moistens relatively dry food and facilitates deglutition, but it is misleading to foster the idea that in man it has a specific solvent action of any appreciable importance as a digestive juice, since Foster himself says, "on starch, raw or boiled, pancreatic juice acts with great energy, rapidly converting it into grape sugar." [8]

If we look on saliva as conducive in maintaining oral hygiene, then we can easily account for the absence of ptyalin in many animals including all fishes. Moreover, we can see a distinctly beneficent effect of the liquefaction of the starch in man which is so often prepared in such a way as to make it lodge unduly in stagnation areas, and is thus prevented from being easily felt and swept away by the tongue, after the last bite or morsel of food in a meal has been effectively disintegrated and made easily removable by the tongue and saliva.

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# Chapter II

## EMINENT BIOLOGISTS, PHYSIOLOGISTS, DIETITIANS AND THEIR INFLUENCE ON OUR KNOWLEDGE OF ALIMENTARY HYGIENE

During the latter half of the nineteenth century there have been discordant views with regard to the best means of securing and preserving oral and alimentary hygiene. These involved many questions associated with the physical and chemical nature of foods, digestion and assimilation, and the destruction or control of obnoxious bacteria. It may now be well to reconsider some of these ideas in the light of knowledge derived from eminent biologists whose work might be considered perfectly reliable. Naturally the books of my student days toward the end of the nineteenth century gave me the views of authoritative teachers from various countries and from famous biologists in England during the Victorian era, and translations of textbooks by German authors, which in those days were highly appreciated.

The first to which reference may be made is: *The Elements of the Comparative Anatomy of Vertebrates* by Prof. Robert Wiedersheim, the translation of which was made by N. Newton Parker, Professor of Biology in the University of South Wales. This book no doubt provides much useful information for students in Zoology with regard to the comparative anatomy of the jaws, tongue and ”Glands of the Mouth” which as he says "first appear in terrestrial animals, that is from Amphibians (l. c.) onwards. They have the function of keeping moist the mucous membrane which comes in contact with the outer air From being at first almost unspecialized, and giving rise simply to a slimy fluid, they become differentiated later into structures the secretions of which take on a very important relation to digestion . . ."[1] But he brings forward *no* evidence to show that these secretions take on " a very important relation to digestion." Perhaps he may have thought that the water in saliva dissolves shreds and particles of food which are likely to remain too long about the teeth after a meal; but he does not note that the mucus in the saliva entangles the particulate remnants of food and ropes them down to the stomach with each act of deglutition. Nor does he refer to the salts in the saliva which protect the enamel of the teeth and possibly harden or even replace interprismatic organic matter which external agents may have partly destroyed. Rather does he distract attention from the protective nature of the mucus which leaves a lubricating covering or protective film over the superficial layers of the mucous membrane and the surface of the enamel.

Wiedersheim's most interesting observations are with regard to phagocytosis, where he gives a semidiagrammatic transverse section of a portion of the wall of the intestine.[1] This shows "scattered lymph cells in the intermediate layer. . . . Lymph cells in the act of passing through the mucous membrane" and several which have "already passed into the alimentary cavity and are beginning to ingest the contained nutritive particles.[1]"

On the following page he says "The Phagocytes possess the further peculiarity of taking up noxious substances or portions of tissue which have undergone retrogressive metamorphosis, wherever they may occur in the body, thus rendering them innocuous. They thus exercise a kind of superintendence over the body acting as a sort of police force. It is not improbable that this process of ingestion by the leukocytes takes place at every point where the mucous membrane becomes continuous with the outer skin. . . ."[1] Turning next to Sir Michael Foster's views with regard to organized and unorganized ferments, note may be taken of the fact that the proteolytic bacteria of the mouth perform a beneficent function in disintegrating and liquefying albuminous shreds which are liable to putrefy or favor the proliferation of obnoxious bacteria if they are not liquefied and carried away with the food during mastication and deglutition, i.e., so long as what we call the "afterflow" of the saliva continues.

Similarly, the ptyalin in the saliva is important, *while in the alkaline medium of the mouth*, in liquefying starchy foods and so facilitating their removal from stagnation areas. Moreover, the saliva causes the cellulose to become swollen, metamorphosed,[3] soft,[4] and more easily removed by the movements, more particularly of the tip of the tongue. The alkaline mucus and buffer salts protect the enamel from acid which might help to cause erosion or even (with the use or abuse of toothbrush) predispose the neck of the tooth to caries.

For over half a century scientists have taught us the important fact that tactile perceptions and judgments are more accurately appreciated by the tip of the tongue than by any other part of the body—even more accurately than the palm of the last phalanx of the finger.[2] Those tactile perceptions, discriminations and judgements are important from the viewpoint of oral hygiene when further enhanced by the sense of taste "which may be broadly classified into acid, saline, bitter and sweet tastes. Sapid substances have the power of producing these sensations by virtue of their chemical nature."[3]

The foregoing observations indicate the necessity of paying attention to the physical and chemical nature of the food, as the tongue is automatically stimulated to act mechanically on every shred of food in such wise as to rid the mouth of all objectionable relics of food, provided that through mismanagement of young children their habits and tastes have not been perverted, depraved or rendered somewhat insensitive.

To indicate that Sir Michael Foster was beginning to give up some of the misleading ideas with regard to the digestion of starch which he, and at later date Weidersheim, had taken up, let me quote a few lines from Huxley's *Lessons in Elementary Physiology,* the fifth edition of which was revised by M. Foster and Dr. Lea in 1900. Therein we find it said that "all the starch which is eaten as food is converted into sugar in the alimentary canal, and reaches the liver as sugar."[5] And referring to the chemical change brought about by "a peculiar substance called *ptyalin* which has certain very remarkable properties," he adds "but its importance must not be overestimated. For in many animals the action of the saliva on starch is very slight, and moreover the larger part of the starch we eat is digested, that is charged into a sugar, while the food is in the intestine."

Thus he leaves us wondering for what purposes the "very remarkable properties" of the saliva exist, or why Wiedersheim and later physiologists came to believe that these secretions "take on a very important relation to digestion."[1] While explaining the "Function of Alimentation" throughout the 60 pages which he devotes to this subject, it would appear that Huxley and Foster overlooked the importance of the physiological requirements of the alimentary canal with regard to maintaining it in a hygienic state.

In his subsection on Mastication and Swallowing, Huxley gives a very good description of the cavity of the mouth from the lips in front to where the hard part of the palate ends, and the communication between the mouth and the upper end of the throat commences. He refers to the movable floor of the mouth "constituted by the lower jaw, and the tongue, which fills up the space between the two branches of the jaw" and notes that "arching around the margins of the upper and lower jaws are the thirty-two teeth."[5] This complicated cavity and entrance portal of disease requires to be kept clean or in a hygienic state and dentists throughout the nineteenth century have continuously attempted to inculcate the idea that this can be brought about by the regular use of the toothbrush, floss silk and at a later date antiseptic and alkaline mouth washes.

During a corresponding period, the medical profession has been looking on and writing about the principles of dietetics while neglecting the principles of alimentary hygiene, except perhaps when good results may have been expected from the administration of aperients of other forms of medical treatment. Huxley's section on "Mastication and Swallowing" is, as already indicated, good from an anatomical point of view but from the point of view of the hygiene of the thirty-two teeth to which he refers, it is remarkably unsatisfactory. Little or no indication is given as to why the mouth so frequently gets into an insanitary state, though as a comparative anatomist he must have known quite well that the teeth of animals but rarely showed such signs of malhygiene and disease as those so constantly seen in man. Yet the prevention of the unhygienic state of the mouth and associated diseases are as easily prevented in civilized communities as they are among savage tribes except when "the modern and almost universal craze which just now exists . . . for eliminating all the inert or innutritious matter from the food we eat."

Fortunately the unhygienic state of children's mouths and the prevalence of dental disease may surely be prevented by a simple and agreeable regimen which has been found to be very satisfactory since man began to inhabit the world. It would, however, appear that *nutrition* and *the digestion* of food, caught the imagination of dietitians during the nineteenth century.

It was easy and convincing to show that in a glass bottle, finely ground and prepared food was more rapidly digested than coarse unmasticated lumps of food. It was equally easy for medical men to overlook the fact that food which stimulated efficient mastication concurrently tended to clean the teeth and leave the mouth in a hygienic state apart from its effect in promoting healthy activity of the tongue and muscles of mastication.

Thus, apparently it was that the nineteenth century physiologists laid hold of a theory which could readily be exhibited in well equipped laboratories and so the attention of dietitians became fixed on the Digestive Juices and the Work of the Digestive Glands. But the alimentary canal is not a glass bottle open only at one end. The alimentary canal commences with the mouth, where food and bacteria enter, and terminates when unwanted relics of food and other by-products formed during digestion are ejected. And it must be remembered that this digestive tract requires to be kept in a hygienic state if obnoxious substances and especially bacteria are to be kept under control till they can be evacuated. Huxley refers to the "Effects of the Several Food-stuffs" saying "the *salts* which leave the body are largely the salts which are introduced in the food. It might therefore at first sight appear that they are merely unavoidable constituents of food which are largely passed without change throughout the body. But this is not the case[5] and he gives good reasons for saying so. Evidently, he does not think it is very necessary " to distinguish the *Essential* food-stuffs, or proteids, from the *Accessory* food-stuffs," or heat producers such as fats and carbohydrates, desirable though they be, because "it is quite possible that an animal fed with perfectly nutritious proteid matter should die of starvation." Unfortunately, Huxley fails to note the value of innutritious bulk, such as cellulose which like other vegetable and animal foods are generally associated with traces of stimulants, such as vegetable acids, conducive to the satisfactory working of the digestive organs and alimentary hygiene.

The next branch of biology to which attention may be drawn and from which we derive useful information with regard to hygiene in diet is botany. Apart from the fact that all the essential elements of food required by the higher animals are contained in or derived from the plants upon which they feed, we should recall that symbiosis[7] may play an important part in the hygiene of the mouth and no doubt other parts of the alimentary canal. Under natural conditions, micro-organisms cannot be prevented from getting into the mouth even of breast-fed infants, and Nature cannot be blamed for making a virtue of necessity by letting harmless or rather beneficent micro-organisms liquefy albuminous shreds and starch granules so that they may be flushed away by the hydrodynamic force of the saliva during the crushing and disintegration of the cellulose before swallowing.

For several centuries the correlation of dental caries and the undue consumption of sugar has been observed, and though it is not necessary to recapitulate the reasons which led the dental profession to recognize the fact, it may be well to give a resumé for pediatricians who read *Dental Items of Interest.* It is abridged from a recent article by Dr. A. C. Fones in *The Journal of the National Dental Association* on *Sugar and Dental Caries* a compendium of which was specially condensed for the *Dental Record*. The three last paragraphs may be enough for present purposes. He says "Among the peasant classes of Italy, Greece, the Balkan States, Germany, etc., where the diet consists mainly of coarse foods, vegetables and fruits, but where free sugar is a luxury and cannot be indulged in, decayed teeth are the exception and not the rule. This is also true of the Esquimos, the African Negroes, the American Indians, the Maoris and many of the South Sea Islanders.

"During the examination of many hundreds of mouths, especially those of Italians, it was noted that many of them had thirty-two perfect teeth without a cavity or filling, and yet those men had reached the age of twenty-one without even owning a toothbrush and had consumed quantities of starchy foods. They stated that they did not care for sweetened foods, and it was found later that the free sugar consumption in Italy averages but thirteen pounds per head per annum—less than a teaspoonful a day. The medical profession is, to a great degree, responsible for this situation, for the family physician has taught mothers to believe that free sugar is an essential food for growing children."[8]

In 1900 Doctor, now Sir, Robert Hutchison said "The intestine seems to require a certain amount of *ballast* probably to act as a stimulus to its peristalsis" and continuing notes that "If herbivorous animals, such as rabbits, are fed upon a diet which leaves little or no residue, it has been found that they suffer from affections of the intestine which may even prove fatal, whereas such effects can be avoided by adding to the food any material which leaves behind an unabsorbable residue. Even in the case of man, who has a consideraby shorter intestine, it is observed that a diet which is practically completely taken up into the blood such as one composed exclusively of meat, is prone to be accompained by intestinal disturbances."[9] This has been confirmed experimentally in monkeys by Dr. Percy Howe (a past President of the American Dental Association 1927) in "Some Experimental Effects of Deficiency Diets." The following is a quotation from one of Dr. Howe's communications with regard to my recommendations dealing with foods which "cause the teeth to be vigorously used, and also calls attention to the cleansing effect of the fibre of the food. These are excellent recommendations. The use of an organ is necessary for its development. Disuse means atrophy. The cleansing effect of the fibrous food is evident, and induces firm gums and general well being in the mouth. But just as the roughage of the food acts in the mouth, so does it act in a more important manner for systemic health in the intestinal tract. Here it keeps clean the intestinal absorption walls and strengthens the muscular tone. It prevents stasis and gives bulk to the food mixture which indicates that more good is received from the food taken . . . In an experimental way this is markedly shown, for animals that have intestinal derangement respond very promptly to the use of filter paper, which, of course is pure cellulose."[10]

With regard to sugar which after ingestion does not leave behind an unabsorbable residue, it seems difficult to understand why such a high authority on dietetics as Sir Robert Hutchison should have said at an important meeting that he "was prepared to admit theoretically that sugar might be expected to be a factor in the production of caries but sugar was an extremely valuable food for the child and it might be worthwhile to pay the price of a certain amount of dental caries."[11]

Surely it would have shown more wisdom if he had referred to the importance of ballast, detergent foods and other developmental and hygienic stimuli which, given at the proper time in sufficient amounts, would prevent sugar from doing any harm. If such developmental and hygienic stimuli are absent, the jaws hardly ever develop sufficiently to permit of the proper growth of the jaws and beautiful arrangements of the teeth; while resulting irregularities of the teeth predispose to dirty discoloration and caries, frequently culminating in loss of teeth which disfigure the features throughout life.

In a state of nature, sugar is almost always diluted with a considerable or large quantity of water together with a certain amount of vegetable acid and other substances which stimulate the flow of saliva and the self cleansing of the mouth, while at the same time the fibrillar cellulose accompanying these sweet or sapid foods stimulates the pleasurable activity of efficient mastication and consequently also the development of the jaws. In addition to this the physical nature of firm fibrillar food polishes the teeth, dislodges obnoxious debris and keeps the gums in a firm and healthy state.

Unfortunately, probably originating from an instinct which was eminently desirable when nutritious food was hard to procure and often rather hard for young children to do more than suck, a dietetic regimen was gradually introduced which inculcated the idea that on commencing to wean an infant it should be given cow's milk, thickened with flour, or bread crumbs to break up the rather indigestible casein formed from the protein during digestion. Apparently this is the origin of what is now know as "pap feeding." But this was not found to be altogether satisfactory and a craze for more nutritious and stimulating food was instituted. The high caloric value of sugar was readily seized on to justify the recommending foods of a sugary nature, and this together with the knowledge of its complete assimilabilty, allowed it to become regarded as particularly beneficial for growing children and soldiers on the march. Unfortunately the effect of mannitic fermentation in locating fermentable sugars in retention areas about the teeth was unknown to nurses, mothers and even family doctors, and thus the giving of sweets or bread and milk became a common practice.

That there should be some interval between the finishing of the last meal of the day and the time of going to bed was overlooked and but little importance was laid on the value of bulk, ballast and detergent foods which like cellulose help to stimulate mastication and maintain a hygienic state of the whole alimentary tract. The benefits derivable from the new idea that the cause of the prevalence of caries is the refinement and softening of the food were overlooked with regard to the fact that when fibrous food is chewed together with non-fibrous, the non-fibrous is swallowed first, and the fibrous follows after further chewing. This fact may be easily observed when eating meat and potatoes, the potato being swallowed a considerable time before the meat, which requires longer chewing. The fluid and finely ground part, which is principally carbohydrate from the potato, mixed with the saliva and other juices, is pressed backward to be swallowed, while the roughened surface of the dorsum of the tongue arrests the passage backwards of the fibrous part of the food by pressing it against the rugae of the palate. The tongue then returns this fibrous part to the side of the mouth to be further disintegrated.

If an unsavory simile may be used, this process may be likened to the mopping up of the dirt and water from a floor which is being cleaned; the fibrous mop or cloth is rubbed on the floor, and the water and dirt which it gathers up are wrung out into the bucket, and the mop again applied to the floor, the dirt and water soaked up, and the process repeated. This is essentially nature's method of cleaning the teeth, and is, I believe, more efficacious than a toothbrush, as it polishes the surface of the teeth and creates a healthy flow of saliva while removing the non-fibrous foodstuffs. Another effect produced by the elimination of the coarse and fibrous parts of many foodstuffs is to encourage the habit of swallowing the food without much mastication. This is especially the case with children who are brought up on soft foods.

Now, although civilization has brought about the removal of Nature's toothbrush, it is, as it were, an avoidable accident, caused by what Sir Henry Thompson recognized to be a "want of elementary knowledge of the first principles of digestion."[6] And if we look into the more or less distant future we can easily perceive that civilization will bring back in some form or another, that which it is at present so careful to remove, and we may look forward to the time when the food for the civilized may be less conducive to caries than the food of the uncivilized is today.[12] It may indeed be said that during the whole of the last century, apart from toothbrush drill and antiseptic mouthwashes, the maintenance of a healthy state of the mouth and alimentary canal was left to take care of itself or rather prevented from doing so till disease necessitated the advice and attention of the doctor and dentist. Prevention was seldom seriously thought of, and unfortunately the idea that as far as caries was concerned, the teeth of civilized man had degenerated was taken for granted; while the newer knowledge with regard to heredity and the continuity of the germ plasm, for which we are indebted to scientists in botany and zoology, was never mentioned in students' textbooks dealing with dietetics and the diseases of the teeth for many years after the beginning of the present century.

Fortunately, the blaming of heredity or making it an excuse for the prevalence of dental caries, together with the distortion of the jaws, have now almost completely vanished from authoritative dental manuals. Nevertheless further remarks will be made supporting the foregoing views when dealing with developmental effects of detergent foods which stimulate the normal growth of the jaws and regular arrangement of the teeth, while referring to the valuable work of eminent dentists of the nineteenth century on both sides of the Atlantic who have done so much to establish the macroscopic and microscopic pathology of dental disease, and Nature's method of maintaining alimentary hygiene.

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# Chapter III

## SOME EMINENT 19th CENTURY DENTISTS AND THEIR INFLUENCE ON OUR KNOWLEDGE OF ALIMENTARY HYGIENE

The various parts of the alimentary canal are wonderfully designed for the prehension and preparation of food for digestion, nevertheless the disorders and diseases of this *prima via* are a more or less constant source of trouble, affecting the whole system and worthwhileness of life.

Naturally much thought and research has been indulged in to discover why animals are so free from dental caries and associated diseases throughout life. It is not my intention to dilate on this subject. Nevertheless, considering the lamentable state of the teeth of civilized man, woman and child, a brief reference to the work of some highly distinguished dentists and medical men who have interested themselves in the subject seems to be eminently desirable. Particularly is this necessary as the instructions given to medical students on the diseases of the teeth are generally quite inadequate for all practical purposes.

In 1816 a book was published entitled *A Practical Guide to the Management of the Teeth: Comprising a discovery of the origin of Caries, or Decay of the Teeth, with its prevention and cure,* by L. S. Parmly, Dental Professor. Firstly, it appears to have been published in Philadelphia (1816); the next edition was published in London (1818), and in the following year, another edition was published in Philadelphia.

"This was the fourth dental work published in America and like its predecessors it was primarily for popular consumption and advertising purposes . . . It is well written, setting forth the author's principles and practices . . . together with his discovery of the external origin of caries and his advocacy of cleanliness as a preventive."[1] Unfortunately, Parmly lived long before Pasteur's work on bacteriology and fermentation was published, but he came remarkably near to the chemico-parasitical theory of the etiology of caries when he wrote, "if we attend to the commencement and progress of the disease, it appears evident, that the cause is of an extraneous nature . . . that it first affects the enamel at one point and that this point is in a situation most liable to be acted upon, by the relics of the food and beverage which, from heat and stagnation, undergoing a putrefactive fermentation acquire a sufficient solvent power to produce disease."[2]

Parmly's recognition of how civilization has come to have a deleterious action on the teeth may be observed in the following quotation, "The teeth of the savage are generally sound and regular, and no accumulation forms to deface them. But this is different in civilized society, refinements in the culinary art give the food a greater tendency to acquire noxious powers and form chemical combination." [3]

Among the notable observations which he made was that "the molars are usually more decayed than any other teeth. The incisors of the upper jaw are also very frequently affected in this way, while those of the under jaw are very seldom known to decay." [4]

The explanation which he gave for the variations in the incidence of caries in the molars and incisors is not altogether satisfactory and will be referred to later. Here I would only say that considering the state of knowledge with regard to the causation of the diseases of the teeth when he wrote his book and the good use he made of his unique opportunity to establish the fact that "caries universally commences externally," [5] it may come as a surprise to many that the leading dentists who followed him gave him no credit for making this most important observation.

The great error in Parmly's work was his insistence on the efficacy of artificial methods of preventing dental diseases when carried out according to his instructions, and belauding his own "dentifrice apparatus."[6]

In 1835, another practicing dentist, William Robertson, published a book on "The Diseases of the Teeth in which the Origin and Nature of Decay are explained, and the Means of Prevention are pointed out." He followed the same lines as Parmly, and elaborated the theory more fully. He claimed that acids are formed from the food particles which were liable to lodge in certain situations, and so brought about the localized destruction of the tooth. The prevalence of caries he attributed to the preparation of food which rendered it more liable to be retained about the crevices of the teeth. Neither Parmly nor Robertson seems to have taken any special interest in the normal physiological self-cleansing processes in the mouth. Nor did they suggest the necessity for any dietetic reform. Parmly advocated a sort of special toothbrush, waxen silk thread, and common table salt as being the best dentifrice. Robertson advocated the toothbrush with the up and down motion. He, however, recognized "that in the vast number of cases, from the deeply indented and irregular structure of the teeth, it is not practical by the most rigid attention to the rules of cleanliness, to prevent the decomposition of food in some of the situations already noticed." [7]

Now let me refer to the work of Sir John and Sir Charles Tomes whose names have figured prominently in dental literature especially during the latter half of the 19th century. In the preface to the first edition of his *System of Dental Surgery,* and reprinted in the second edition, John Tomes says "an attempt has been made to produce within the limits of a manual, a strictly practical work on Dental Surgery" (1859). I am doubtful, however, whether his attempt was altogether successful for, even with the help of his son Charles, in this second edition, 239 pages were devoted to teething, which concluded with a figure of a hippopotamus' tusk, the cutting edge of which, from want of antagonism, and the consequent absence of wearing away, gradually advanced until it entered the pulp cavity, and thus put an end to the further development of the tooth. They described what they considered "the most perfectly developed enamel" and say any departure from this condition may justly be regarded as a predisposing cause of caries, the degree of predisposition being proportional to the relative amount of porosity in the tissue. They deal with the Pathology and Etiology of Caries in the Appendix but do not say anything about prophylaxis or the prevention of dental caries at all. This, in a manual of 748 pages, evidently did not seem to be "strictly practical" presumably because "so much of the dental surgeon's time is occupied in combating caries and its effects." [8] The omission of any reference to prophylaxis may, however, have been a realization of the fact that animals which do not use artificial means of cleansing the teeth are far less subject to caries than are the more civilized peoples who carefully follow the usual instructions with regard to toothbrushes, dentifrices and mouthwashes as advocated by Parmly, Robertson and their followers. However, in the fourth edition of their manual, J. and C. S. Tomes commence a chapter on the treatment of caries as follows:

> "The great prophylactic against caries is cleanliness as is well exemplified by the rarity of its occurrence upon smooth and fully exposed spots. An experiment of Miller's of great significance, determined the amount of acid by two equal infections, the one prior to, the other after, the careful cleansing of the mouth with toothbrush, floss silks, and toothpick, the amount of the latter being often as low as one-fourth of that produced by the former, while after the use of strong antiseptics the amount may be reduced almost to nil. There is no known solution, alkaline or antiseptic, applicable in the human mouth, which will penetrate between the teeth or to the bottom of fissures and cavities when these are filled with food, in sufficient quantity to have any appreciable effect. Therefore, before all antiseptics or alkaline washes come the toothbrush, toothpick, and floss silk." [9]

This is followed by two pages of prescriptions based on Miller's ideas together with a few comments by Messrs. Tomes. It is lamentable that notwithstanding all the knowledge that scientists, including some of the most learned exponents of bacteriology, developmental anatomy, heredity, physiology and odontology have given us, no attempt was made to investigate and explain the reasons why animals and primitive man almost invariably had clean teeth and healthy mouths. Neither was any recommendation made for a dietetic reform such as would not only stimulate normal growth of the jaws but also spare us the time, trouble, and expense of artificial devices, except insofar as they might be of temporary value.

Turning now to the views of the most celebrated French dentist, let me quote the tribute paid by Henry Sewill who wrote,

> "Magitot's researches [10] were among the most valuable of this period, and they are interesting as foreshadowing future discoveries and presenting facts which, at the time, were inexplicable. He produced close imitations of caries by submitting teeth—sometimes protected at all but one part of their surface—to the actions for prolonged periods of very dilute solutions of mineral and vegetable acids. He produced similar effects with fermentable solutions composed of sugar with organic matter." [11]

Magitot's research with regard to the "Relative Frequency of Caries in Different Classes of Teeth" supported by the researches of "various observers" on the same subject have been of the greatest importance to all who were anxious to know the solution of the problem of the prevalence of caries among the civilized, who so frequently indulge or even overindulge in the most nutritious food, supplemented with confectionery and sugary adjuncts. After giving Magitot's statistics of 10,000 cases collected to show the relative frequency of caries in the different kinds of permanent teeth, Sewill says,

> "The first point which attracts attention in those tables is the great relative frequency of caries in the first molars; the next, the much greater frequency of the disease in front teeth of the upper jaw than in those of the lower." [11]

He admits that no entirely satisfactory explanation of the ratio of frequency in the several classes of the teeth has yet been afforded. Nevertheless, he undoubtedly maintained that

> "the localization and the incidence of caries are certainly determined mainly by the presence of inherent flaws in the enamel of the teeth attacked; but we cannot yet account for the fact that certain classes of teeth are more than others the seat of these defects."

Similarly we may note that Dr. W. D. Miller in 1903 said, "The question of the different susceptibilities of different teeth still remains an unsolved problem." [12] Within a year after hearing Miller make this statement, I published a few articles in the *Dental Record* [13] which seem to have given a solution to the problem, and for the sake of brevity I shall only quote a few extracts from the last page of the late Dr. Harry Campbell's pamphlet, entitled "Oral Hygiene" (Reprinted from the *Medical World,* Dec. 20th, Dec. 27th, 1935 and January 3rd, 1936).

"*Relative Tendency of Individual Types of Teeth to Decay:*—The upper central incisors are twenty times more frequently attacked by caries than the lower. The molars taken collectively are five times more frequently attacked by caries than the incisors, though they are more calcified by two per cent (Tomes, Black).

"From 10,000 teeth collected by Magitot, the relative frequency of caries in the incisors and canines was as follows:

| | | | | |
|---|---|---|---|---|
| All calcified at the same time. | Central Incisors | 642 | Superior | 747 |
| | | | Inferior | 30 |
| | Lateral Incisors | 777 | Superior | 447 |
| | | | Inferior | 70 |
| | Canines | 515 | Superior | 612 |
| | | | Inferior | 30 |

"In examining these different groups, it will be found that the tendency of a tooth to become carious is in direct proportion to its tendency to lodge carbohydrate debris. What could better show the influence of external factors in the etiology of caries and the unimportance of intimate dental structure?"

Let me now refer briefly to the work of Miller and Underwood as presented before the Dental Section of the International Medical Congress in London, 1881, which served to revive the interest in the parasitic theory of dental decay. They rejected the chemical theory and stated their conviction that, "in the decay of the hard tooth-structures two factors have always been in operation: (1) the action of the acids, and (2) the action of germs."[14]

This theory as Dr. Miller recognized "marked a great step in the advance of anything hitherto accomplished in this direction." Professor Miller's own contribution may now be referred to a little more fully. His *magnum opus* entitled *The Micro-Organisms of the Human Mouth,* was published in English in 1890. It was his endeavor in this book to "bring about a better understanding of the nature and extent of bacteritic growths in the human mouth, of the disastrous effects which they are capable of producing, and, accordingly a more proper appreciation." It may also be said that his work owes its position in dental literature to his recognition of the progress of bacteriology, together with his appreciation of Pasteur's work on fermentation. Miller notes that "as early as 1857 Pasteur showed that the transformation of sugar into lactic acid depended upon a species of micro-organism." Of special importance, too, are Miller's experimental productions of caries. Dealing with artificial decay he said, "the chief object of his experiments was to produce the microscopic appearances of decay of the teeth, since it had already been proved by Magitot beyond doubt that by various means *macroscopical* appearances may be produced which are identical with those found in decay."[14] Miller records his own research as follows:

> "I cut up a number of teeth which were perfectly sound, but of different density, into pieces of different size, and placed them into a mixture of saliva and bread. This mixture was kept for three months at a temperature of 37°C., and during the course of the experiment frequently renewed. At the end of this time I showed a number of these pieces to a well-known dentist of thirty-three years' standing, and asked him if these were not peculiar cases of decay. He replied by saying that he saw such cases every day in his practice."[14]

But although Miller's artificial production of microscopic appearances of caries confirmed what was seen in the macroscopic appearances produced by Magitot's methods, it did not account for the extraordinary increase in the prevalence of decay which we see at the present day, nor for the relative frequency of the disease in different classses of teeth in the same mouth. To give a more complete idea of Miller's views with regard to the increased prevalence of caries in the more highly civilized countries, and to what he considered the best means of preventing the disease, it seems desirable to make a few further quotations from his book, wherein he says:

> "That the frequency of decay is greater in civilized races than among savages has also been established by numerous observations. . . . There is no doubt that a deterioration of the teeth accompanies the progress of

civilization. The reasons for this are many. The mode of life of most uncivilized races not only conditions a sound, well developed body, but the osseous system, of course including the teeth, shows the same vigorous development, and above all a compact structure[14] . . . The quality of the food also exerts an influence on the teeth not to be underrated. They form no exception to the rule that an unused member will be less perfectly developed than one constantly used.

"The pressure brought to bear upon the teeth by mastication causes a more lively circulation in the periosteum and in the pulp, thereby inducing an increased deposit of lime-salts in a more complete calcification. Practical experience also teaches that children brought up on soft food (broths, paps etc.) generally have bad teeth. If a race of human beings or animals were to make no use of their teeth for several generations we should expect to find a gradual deterioration of the dental structure. It is to say the least, highly probable that the soft quality of many of our foods, as compared to more uncivilized races, conditions a soft, porous dental substance, as well as an imperfect development of the jaw bone, and a concomitant crowded position of the teeth."[14]

In his chapter on the Etiology of Dental Decay, Miller says he considers "starch and amylaceous substances more detrimental to the teeth than sugar, particularly as sugar being more readily soluble, is soon carried away, or so diluted with saliva as to be rendered harmless, whereas amylaceous matter adheres to the teeth for a greater length of time and consequently manifests a more continued action than sugar."

It would seem from this statement that Miller puts more importance on his own interpretation of the static laboratory experiments he made than on the fact that

"most authors give sugar the chief place among the foods which exert an injurious action upon the teeth," or that "at present sugar is universally regarded by dentists, as well as layman, as injurious to the teeth."

Summing up his chapter on the Etiology Of Dental Decay Miller says:

"Those factors which contribute to restrict the occurrence of decay of the teeth, are in my opinion (1) a mode of life favorable to the development of the whole body, (2) the use of food which is sufficiently hard to afford the teeth the exercise necessary for their vigorous development, (3) the use of food which does not undergo an acid fermentation in the mouth."

With regard to (1) we need not make any objection. With regard to (2) we may reasonably deny that hard food is necessary for their vigorous development. Certainly before birth and until the child is weaned there does not seem to be any need whatsoever for hard food to ensure vigorous development of the teeth. Finally with regard to (3) there are so many desirable foods which undergo acid fermentations in the mouth if allowed to remain unduly in the crevices or uncontrolled by physiological means, (e.g. alkaline saline, mucus and buffer salts) that to exclude their use would be altogether impracticable in a civilized community.

As is well known, Miller's influence on the dental profession was greater than that of any other dentist in England or abroad, as may be exemplified by giving a few quotations from two of the first textbooks which, as a dental student, I read after graduating in science and medicine.

Henry Sewill in his manual *Dental Surgery for Students and Practitioners* says:

> "To understand the nature of caries it is necessary to first bear in mind that enamel and dentine are soluble in acids which often exist in the mouth, and that inherent structural defects in the enamel and dentine presently to be described, both furnish in a large number of instances, lodgment for acid forming substances and render the ill-formed portions of the teeth easily acted upon and destroyed.
>
> "The active agents in caries are acids and micro-organisms. The acids principally lactic, malic, butyric, and acetic, are mainly the products of putrefaction and fermentation, set up in fragments of organic matter, food, mucus and epithelial scales, which are commonly present in the mouth.
>
> "These acids are often assisted by others derived from different sources. Some may be secreted by the mucous membrane. The normal secretion of the membrane is small in quantity and slightly acid. In health the acid is at once neutralised by the alkaline saliva, with which it mingles but when the membrane is congested or inflamed, the mucus increases in quantity and becomes more strongly acid in character."[11]

The next quotation is taken from one of the most highly appreciated textbooks for dental students in England at that time. In the last decade of the nineteenth century, in the introduction to the first edition, the authors say:

> "It is admitted on all hands that, concurrently with increasing civilisation, there has been a degeneracy in the structure of the teeth which has rendered them less able to resist the ravages of dental caries. . . . In endeavouring to elucidate the causes of the degeneracy of the teeth, perhaps the most important factor is hereditary, and yet it is not at all uncommon to find parents with strong healthy teeth whose children are afflicted beyond the average in the matter of decayed dental organs. This points to some cause other than heredity strictly interpreted, and the *fons et origo mali* must be sought for either in some constitutional taint, or in some faulty development during gestation, or in some errors of diet and hygiene during the early periods of life."[15]

As indicated, this attitude was promulgated by Sir John and Sir Charles Tomes, and I am much inclined to think that it was Sir John who introduced the misleading idea of the structural deficiencies and hereditary nature of dental caries and irregularities of the teeth. They say:

> "There can be no question that the tendency to caries, whether induced by structural deficiencies or perverted functions, is strongly inherited.
>
> "This inherited predisposition so strongly marked in families extends to whole races and probably is often due to defective developments." [16]

With regard to prophylaxis of dental decay, Miller thinks,

> "It must be apparent that there are four ways by which we may counteract or limit the ravages of this disease. We may endeavour (1) by hygienic measures to secure the best development of the teeth; and (2) by repeated thorough, systematic cleansing of the oral cavity and the teeth to so far reduce the amount of fermentable substances as to materially diminish the production of acid, as well as to rob the bacteria of the organic matter necessary for their rapid development; (3) by prohibiting or limiting the consumption of such foods or luxuries which readily undergo acid fermentation to remove the chief source of the ferment products injurious to the teeth; (4) by the proper and intelligent use of antiseptics to destroy the bacteria, or at least to limit their number and activity." [14]

It is regrettable that these four aphorisms should have diverted attention from all useful considerations with regard to the importance of the physiology of oral and dental hygiene, as also have they distracted attention from the all-important dietetic habits engendered by the use of firm fibrillar foods of a detergent nature which stimulate mastication and the hygienic activity of the salivary and mucous glands, as likewise do such foods stimulate the normal growth of the jaws and the regular arrangement of the teeth.

Miller says,

> "Most authors give sugar the chief place among the foods which exert an injurious action on the teeth—again a conception that is not quite right. It is true that constant breathing of sugar-dust exerts a very destructive effect upon the front teeth in particular, known as sugar decay (Zucker-caries). In general, however, the chief role in the production of decay is performed by bread, potatoes, etc., not only because they produce more acid, but because they, on account of their insolubility, may remain for a long time sticking to or between the teeth, whereas the readily soluble sugar is soon diluted or carried away." [14]

The foregoing quotation indicates a serious disregard for the fact that the mannitic fermentation of sugar gives rise to a gum which is often easily seen in the crevices of the molar teeth for hours after chocolate or other colored sweets have been eaten at the end of or between meals. The harmfulness of sweets has been more fully recognized in recent medical and dental literature as also is the correlation of dental caries and eating sweets.

In recent medical and dental literature I cannot recall having seen any support given to Miller's belief that "The chief role in the production of decay is performed by bread, potatoes, etc." Moreover, in recent researches and observations we have overwhelming evidence that most authors are quite right in giving sugar the chief place among the foods which exert an injurious action on the teeth. The following list from authoritative sources should be sufficient for everyone interested in this controversy:

(a) Campbell, H., 1936, "What is Wrong with the British Diet," pp. 45-48.

(b) Pitts, Arthur T., 1916, "The Care of the Teeth," pp. 38-40, 41, 91, 92.

(c) Fones, Dr. A. C., J. Wheatley, M.D., C. E. Hecht, M.A., etc. in "The Gateway to Health," 1921, Ed. by C. E. Hecht, pp. 64, 65. "Why Worry about Sugar" (C. E. H.), "Sugar and Dental Caries" (A. C. F.).

(d) In the great Compilation of the Research Commission of the American Dental Association on *Dental Caries,* Miller's supposition that the chief rôle in the production of caries is produced by bread, potatoes, etc. is discreetly omitted.

(e) In addition, the textbooks of J. F. Colyer and Evelyn Sprawson, as likewise the authors taking part in the chapters dealing with etiology and prevention in Sir Norman Bennett's similarly authoritative work on "The Science and Practice of Dental Surgery," give sugar the chief role in the production of dental decay. So, too, the leaflet for the use of parents on the prevention of decay in teeth which has been approved by the Council of the Society of Medical Officers of Health emphatically urges the withholding of sweets and sugary foods especially when taken before going to bed.

I have referred to this subject at some length for two reasons, the first is that static laboratory experiments are liable to be very misleading. Bread and potatoes in an incubator and left at rest several hours before renewing or adding fresh bread and potatoes may certainly give rise to more acid, but in the mouth, particularly when there has been ample mastication and stimulation of the salivary glands, assisted by a copious flow of saliva and complex movements of the tongue, lips, and cheeks, all of which help to carry away the starch, the soluble starch, and grape sugar before any harmful retention of acid can take place. The second is that to exclude bread, potatoes, etc. is impracticable.

Miller pays tribute to G. V. Black, saying that,

> "In America, Black has entered upon the study of micro-organisms of the human mouth with great zeal,[14] and refers to mannite fermentation (mucous and gum fermentation). . . . The products of this fermentation are a kind of gum (viscose) closely resembling dextrine. . . . Black observed a similar fermentation caused by the action of the various mouth bacteria (micrococci) in saccharine solutions." [14]

The chemical equation given by Schutzenberger quoted in my first book on the *Cause and Prevention of Decay in the Teeth,* is as follows:

$$\underset{\text{Cane Sugar}}{25\ (C_{12}\ H_{22}\ O_{11})} + \underset{\text{Water}}{25\ (H_2\ O)} =$$

$$\underset{\text{Gum}}{12\ (C_{12}\ H_{20}\ O_{10}} + \underset{\text{Mannite}}{24\ (C_6\ H_{14}\ O_6)} + \underset{\text{Carb. Diox.}}{12\ (CO_2)} + \underset{\text{Water}}{12\ (H_2\ O)}$$ [17]

> "To this I added the observation that viscous gum acts as a very effective barrier to the beneficent influence of the saliva, and as this fermentation takes place along with lactic acid and other fermentations and the deposited gum acts as a food-catcher, retainer, and acid fermentation protector, we need scarcely wonder that there is a popular impression that sweets are bad for the teeth."

Here we may note also that J. and C. S. Tomes say—and I never heard of anyone denying it—that

> "certain articles of diet appear to have a directly mischievous action; thus it has been found in children who have been soothed with a sucking bag (containing sugar and milk) the crowns of the upper incisors are rapidly destroyed, though the molars would escape." [8]

(Think of the position of the sugar and milk sucking bag in relation to the upper incisors and the mobile tongue which protects, and together with the saliva tends to keep the teeth free from the effect of fermenting sugar and milk which tends to lodge between the upper teeth.) Unfortunately, on the following page, the Messrs. Tomes say:

"There can be no question that the tendency to caries, whether induced by structural deficiencies or perverted functions, is strongly inherited." [8] This statement is quite erroneous and fosters a misleading attitude of mind for, as a general rule, it is dietetic habits that are passed on from one generation to the next rather than good or bad teeth, and so we may join hands with the biologists who have discarded the idea that acquired characteristics are transmitted.

A review of the work of the eminent 19th century, indicates that the pathology of caries was fairly thoroughly revealed both macroscopically and microscopically when Miller published his most important work entitled *The Micro-Organisms of the Human Mouth,* but he gave no solution to the problem of why there was such an extraordinary increase of caries notwithstanding the phenomenal progress in science and medicine which characterizes that century.

When I became a student in dental surgery early in the last decade of the 19th century, it soon became apparent to me that it was not the solution of the problems of etiology and pathology, but the cause of the increasing prevalence of dental diseases, especially caries, that was so perplexing not only to the most erudite of the dental profession but also to medical officers of health, dietitians, biologists and medical practitioners generally.

It was said in one of the first and most authoritative books I read on the subject that:

> "It is admitted on all hands that, concurrently with increasing civilization, there has been a degeneracy in the structure of the teeth, which has rendered them less able to resist the ravages of dental caries." [15]

In America, however, Dr. G. V. Black combated the theory that the predisposition of caries exists in the teeth themselves. But he also said he supposed

> "the hereditary predisposition of certain families to caries has been so generally observed that it will not be questioned, and only needs mention." [19]

He does not appear to have observed that what has been regarded as hereditary predisposition to caries was only abiotic or legal heredity, in other words, to racial or family customs in the choice of foods.

> "We are certainly not justified in expecting a predisposition to the formation of acid to exist in the enamel which is essentially an inorganic substance. . . . And I am strongly of opinion that even the rapidity of caries is almost solely due to the kinds of food consumed, together with the other conditions already mentioned . . . and not to any inherent defective structure of the tooth itself. It will probably have struck most dentists, and I have seen it commented upon in works on dental surgery, that honeycomb teeth,

which are the most grossly defective that we ordinarily meet with, are not apparently prone to rapid decay."[20]

Since the end of the last century when W. D. Miller, G. V. Black, J. and C. S. Tomes, Henry Sewill, M. Smale and T. F. Colyer were the recognized leaders of the dental profession, the new views on hereditary promulgated by Naigeli, Strasburger and Weismann have been generally accepted in this country at least, and more than a decade ago it was observed that "meditation" on the facts brought forward by William Robertson of Birmingham, Arthur Underwood and W. J. Milles and other 19th century dentists, including of course

> "the publications of Miller led J. Sim Wallace, in 1899, to put forward the first of a long series of articles dealing with the effect of diet upon the teeth and jaws, and to formulate a regimen introducing into the daily diet those foods which, by their fibrous and sapid nature, would encourage the flow of saliva, and by the exercise of mastication, stimulate the growth of the jaws, and at the same time have a detergent effect upon the teeth and gums. This was the first scientific effort at the prevention of dental caries, diseases of the gums and irregularities of the teeth."[21]

Anyhow these were the words used by our most renowned historian in the dental profession, and how far the "effort" was successful may best be indicated by giving brief extracts and comments on the long series of articles referred to, which were naturally followed by still further communications stimulated by encouraging observations and impartial trials followed by the most excellent results one could ever have dreamed possible.

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# Chapter IV

## CIVILIZATION AND DIET IN RELATION TO THE DEVELOPMENT OF THE JAWS AND THE PREVENTION OF THE DISEASES OF THE TEETH

That the prevalence of caries among civilized people is greater than among savages is a well-established fact, and it is argued that civilization is a predisposing cause of caries. This supposed cause is too indefinite for any practical purposes, and I will endeavor to show that although caries is intimately connected with the advance of civilization, the resulting caries is, as it were, an accident and need not be a necessary consequence of civilization.

In glancing over the history of the civilized we see that much of the advance has absolutely nothing to do with caries in teeth. I think it will be admitted, however, that if we direct our attention to the evolution of the means of obtaining food, and of the processes to which foods are subjected, the investigation may be in a profitable direction.

In the early periods of man's existence there was little social cohesion, and each individual, to a great extent, had to concern himself with securing food, and when he had the opportunity or inclination, with cooking it. Even before the introduction of suitable utensils which could be used for boiling over a fire, it was to a certain extent managed by the introduction of hot stones into the liquid foods, which were collected in whatever utensils were most convenient for holding them. Methods were in use for roasting meat, fish, roots and nuts, which, together with fruit. seemed to have supplied the needs of remote savages.

When we compare such a state of affairs with the various methods of securing food at the present day, and the elaborate machinery (flour mills, rice mills, sausage mills, sugar refineries and meat juice factories) by which many of the foods are refined, not to speak of the processes to which food is subjected in our bakehouses, biscuit factories and kitchens, we see that there is some difference in the food of the present day and that of past ages. It may be said, however, that after all, the foodstuffs have not essentially altered. We require proteids, carbohydrates, fats, water and mineral matter, much in the same proportion as our ancestors, and this is what we get. There is one change, however, which has gone on and is still going on, until it has reached a stage which is absolutely detrimental to the well-being of the teeth, stomach, alimentary tract and body generally. There has been and is a gradual elimination of all the firm, fibrous, inert and undissolved earthy matters which are present more or less in the food of savages. The teeth are no longer used and burnished by these natural toothbrushes and tooth powders, and the stomach and intestines no longer have their movement sufficiently stimulated by the natural excitation of foodstuffs. That there may be authoritative support to the above, I shall quote from Sir Henry Thompson's work on "Food and Feeding." Referring to whole meal bread he says:

> " . . . no portion of the husk of the grain should be removed from the wheat when ground, whether coarsely or finely, into meal. That a partial removal is systematically advocated by some as an improvement is one of the modern and almost universal crazes which just now exists among food purveyors of almost every description, for eliminating all the inert or innutritious matter from the food we eat. This extraordinary care to employ nothing in our diet but matter which has nutritive value, that is, can be absorbed into the system, is founded upon want of elementary knowledge of the first principles of digestion . . . It seems to me to be now almost overlooked that no proper action of the intestines can take place unless a very considerable quantity of inert matter is present in our daily food, existing as materials which cannot be digested . . . When there is a considerable proportion of this in the food the bowels can act daily and regularly, having a mass which they can transmit. When on the other hand, the food is so nutritious as to be entirely absorbed, there is very little solid matter to transmit, and the action of the bowels is therefore scanty, irregular and insufficient. This is, in fact, a very extensively recognizable cause of a great deal of the habitual constipation so prevalent among the middle classes at the present time."[1]

That a craze for eliminating inert matter should be so universal when it is detrimental to the well-being of the body may well cause surprise Why should a craving for the nutritious only have sprung up? The answer is simple. The nutritive instinct is the most primitive, the most fundamental, and the most ineradicable with which we are endowed.[2] Throughout the whole course of evolution, at least to the advent of a moderately high standard of civilization, this desire for the nutritious and aversion to the innutritious has been a beneficent instinct to all who possessed it, for during all that time, however strong was the desire for that which was nutritious, there was always too much of that inert and coarse matter which is now so necessary. I need not point out in how many ways this preference for the succulent and nutritious must have been advantageous to primitive man, who subsisted to a large extent on roots, berries, grain and fruits, supplemented by what little fish or meat he could secure. It will suffice to note that he required to carry about with him a larger and heavier digestive tract than does civilized man,[3] and much of the energy which we can now utilize in other ways was utilized by primitive man in extracting nutriment from coarse, fibrous, and more or less nutritious foodstuffs.

With the advent of civilization there have come the machinery and methods of preparation which strip even the inner husk from the grain, and then grind this already refined foodstuff to an impalpable powder (flour, maize, rice, etc.), to be ready for more preparation by the modern art of cooking. Other means are adopted for extracting merely the juice of roots and plants (sugar). Numerous examples will present themselves to the reader which show how carbohydrates especially are ridded of the fibrous matters with which in their natural state they are mixed. In the case of children's food this process of elimination is carried out to a still greater extent, and many children are brought up on softened derivations of foodstuffs administered in the form of paps.

It is tolerably clear that what was at one time performed by the teeth and stomach is now too largely done by machinery and cookery.

It is important to note, however, that although the food as consumed at the present day is conducive to caries, it is not conducive to inherent or development deterioration in the structure of the teeth. The enamel is formed below the surface of the mucous membrane, and is complete in form and structure before it cuts the gum. And although the teeth are unused, or only partially used, there is no reason to suspect a deterioration of the structure.

If it could be shown that a deteriorated structure of the teeth had been advantageous to the races in which it might be presumed to have originated, then perhaps with the aid of natural selection, the structural degeneration of the teeth might have been brought about. But this assumption cannot be granted. We cannot believe in the degeneration of the teeth themselves unless we wish to believe in the inheritance of something which is detrimental, an idea which has not even the support of the theory of the preservation and augmentation of useful characteristics through adaptive modifications. Indeed we may say that the theory of deteriorated structure of the teeth as promulgated so widely by Sir John and Sir Charles Tomes, with the prestige of the Royal Society behind them, was one of the most lamentable calamities in the history of the elucidation of the causation of dental caries.

When fibrous food is chewed together with nonfibrous, the nonfibrous is swallowed first, and the fibrous follows after further chewing. The same remarks are applicable to fibrous foodstuffs which contain much starch and require chewing. From a physiological point of view also, the fibrous matter, which in the natural state is incorporated with starchy food, ought to be retained, as this necessitates thorough mastication, and so allows the ptyalin of the saliva to act upon the starch, if it is not washed away, and supplies at the same time the requisite inert matter for the proper action of the bowels, as well as supplying the requisite cleansing matter for the teeth. Another effect produced by the elimination of the firm fibrillar parts of foodstuffs is to encourage the habit of swallowing the food without efficient mastication.

The foregoing slightly abbreviated quotations from my own earlier views and those of other authors dealing directly or indirectly with hygiene in diet are given because they substitute a definite and easily verifiable explanation which fits in with known facts, instead of trying to promulgate theories of hereditary degeneration in the structure of the teeth and correlated pitiable development of the jaws, which are not supported by facts or approved by scientists.

Our knowledge of hygiene in diet and the rejection of the assumption of a correlated heredity of the maldevelopment of the jaws, raises questions with regard to facial beauty which is the absorbing concern of a large section of the community, and many aids to its attainment have from time to time been introduced. But these have been largely limited to the care of the skin and superficial applications. Unfortunately "beauty is not simply skin deep, since ugliness goes into the bone." It is but yesterday that any attempt, of a really scientific nature, has been made to examine the causes of dentofacial deformities, and to lay the foundations of knowledge which show how, to a large extent, facial beauty can be secured and how the pitiable disfigurement of large sections of the community may be averted.

The great majority of the irregularities of the teeth result from an insufficient development of the muscles and bones of the jaws. The crowns of the teeth have a certain definite form and size, and these are built up in the substance of a jawbone quite independent of functional activity. Bone, on the other hand, particularly perhaps in the jaws, is to some extent plastic and subject to variations, dependent on the pressure strains to which it may be subjected, and to its adaptability to the soft sister tissues which bear upon it. The primary function of the bone is to withstand pressure strains, and to this it responds according to a well-known law that "the amount of growth in a bone depends upon the need for it." In the case of the jawbones this has been experimentally demonstrated in young animals, by grinding away the crowns of the teeth in both upper and under jaws on one side, so that mastication could not be performed with these teeth. The jaw on the side on which mastication was carried out, developed well but the growth of the jawbone on the other side was deficient. Further, there was defective bone formation in all the bones right up to the skull on the side on which no strains of mastication were possible.[4] Even where bone has been laid down while the pressure strains of vigorous mastication continued, it may become wasted away if the pressure strains are lost. Thus, in those who become edentulous in old age, there is a great reduction in the size of the jawbones, not only from the loss of the bone supporting the teeth, but also from the loss of the bone laid down to withstand pressure strains.

On the other hand, when we examine the jaws of savage children or those of our own Neolithic ancestors whose teeth were well-worn, we find a markedly substantial jawbone with a well-developed angle indicating a direct response to the hard work to which the jaws were put.

Interference with growth of bone is also frequently brought about by long continued ill-health, particularly when this gives rise to muscular weakness and emaciation. How this is correlated with insufficient growth from lack of function is obvious. It has been claimed, however, that certain diseases have a special influence in bringing about irregularities.

It is in very early life that the normal stimulus to the growth of bone is specially desirable. Moreover, at an early age it is most important that the correct relationship of the lower to upper teeth should be secured, for if it is not, the excellent mechanism of the masticatory apparatus is more or less thrown out of gear, and the resulting effects of pressure strains are almost sure to be defective or perverted. The lower jaw is slung loosely by ligaments which hold it in position; but the muscles of mastication hold it more firmly, except perhaps during sleep. When the health is good and the proper stimuli for the development of the muscles are present, the lower jaw tends to be set in the correct position for maximum efficiency in use, and it grows to correspond to this set.

During the first few months of life, although mastication is not performed, the sucking of milk involves a considerable amount of exertion on the part of the infant, rather similar in nature to the action of mastication and deglutition.[5] If this takes place without artificial facilities, so much the better. Even before the cutting of the milk incisors, the instinct to gnaw with the gums develops, and tends to bring the jaws into, or keep them in correct relationship. When the teeth begin to appear, instinctively the child continues to gnaw, and it sets the lower teeth and jaw in the best position for doing this. In fact, the lower and upper incisors come to hold their correct relationship to each other; and as the teeth of the upper and lower sets correspond in relative size, the subsequent arrangement of the relationship of the lower to the upper teeth is under normal circumstances fairly certain. Little adjustments are often naturally made, for one of the functions of the cusps of the teeth is to secure correct relationship of the dental arches. Moreover, when the mouth is kept shut, the tongue tends to act as a "common denominator," adjusting both lower and upper teeth to its even border.

The lower jaw is usually described as consisting of two parts, the horizontal part, or body, and the hindmost part which rises from this to the joint, the ramus. The length of the body of the jaws is increased by deposition of bone on the hindmost border of the ramus. The front or anterior border is concurrently absorbed, and so the fore part of the body of the jaws carries the teeth in position forward, and leaves room for the molar teeth subsequently coming into position. The upper jaw grows backward in a similar way. If the jaws are not sufficiently used and the muscles of mastication including the tongue, not fully developed, the deposition of the bone on the posterior border of the ramus is very frequently insufficient and the anterior part of the body is not carried forward to its normal extent. Nevertheless, the molar teeth come into position, or rather they force their way into position, between the hindmost previously erupted molar and the anterior border of the ramus, and, in doing this they push forward the teeth in front of them so that they either project or become irregularly placed in the insufficiently developed jaw. There is no reason to blame heredity for this; moreover, to do so only leads to apathy in prevention. If the normal development of the jaws is stimulated by the natural pressure strain of mastication, the jaws grow just as well as do the jaws of savages to accommodate the teeth without crowding.

Incidentally, it may be noted that in countries where infants are breast-fed and not submitted to the methods of overenthusiastic "fresh air fiends" in cold and damp weather, the jaws grow relatively well and are properly correlated, but when "colds" affecting the nose are recurrent throughout the winter months, mastication is insufficiently stimulated and the growth of the jaws correspondingly compromised not only on account of the difficulty of breathing during mastication but because of the position of the tongue when lying at rest with the mouth partly open. The dangers of deaths too, from "overlaying" have been greatly exaggerated. It has been shown by the late Dr. W. A. Brend, the chief authority on the subject, that "if these deaths were the subject of efficient inquiry, there is strong reason to believe that the great bulk of them would be found to have been due to natural causes." (*Health and the State*).

The whole subject is, or ought to be, very interesting to orthodontists and those who recognize the important part that diet plays in bringing about facial beauty. Here, however, I must limit myself to a few elementary facts which throw light on the subject. To bring forward the factors which diet plays, it might be well to refer to the effects of mastication with special regard to the development of the jaws but as I have recently gone into this subject rather fully[6], all that need be added to what I have noted in the previous part of this communication are the observations which have been made by distinguished anthropologists.

(Notwithstanding enemy action, a few copies are procurable from the publishers, and my earlier book on *Irregularities of the Teeth* may perhaps be found in Dental Libraries.)

Although the etiology of the malocclusions of the teeth is important from the point of view of facial beauty, oral hygiene, caries, tartar, discoloration, pyorrhea, etc., the attempt on my part to deal with it briefly would probably not be very satisfactory. For those who wish to follow up the subject it may, however, be useful to give a few extracts from the criticism of two famous anthropologists on my views as presented in *The Variations in the Form of The Jaws.* I had the good fortune of meeting the editor of the *American Journal of Physical Anthropology* (the late Dr. A. Hrdlicka), during my visit to Washington, while on my lecturing tour in America, and again while he was in London on the occasion of his giving the Huxley Memorial Lecture. From our conversations, from his contribution to the discussion of my paper in Washington and the review in the journal referred to, I gathered that we are in remarkable agreement with regard to many points on which some distinguished anthropologists appear to differ. Omitting some comparisons with other literature, the following extract from his review indicates his opinions:

"In many aspects the work is of direct interest to anthropology . . . There are a good many observations based on original research by the author. A few examples must here suffice. Under normal conditions there is close correlation between the size of the teeth and that of the jaws; and mixture of races appears to make no exception in this respect. The dental arches of the more primitive people show remarkable absence of those irregularities which confront us in civilized man today. Rachitis does not perceptibly affect the development of the jaws. The tongue plays an important part in moulding the dental arches. The growth of the jaws, as that of other bones, does not proceed evenly throughout its course. Pressure strains act chiefly in stimulating growth in breadth. The factors which tend to cause narrowing of the palate operate, it is highly probable, very early in life. After the milk teeth erupt, practically all the horizontal growth of the jaws is behind the second milk molar. The chin is 'an appearance resulting from the decreasing size of the dental arch,' it being placed as a whole farther back in relation to the body to the jaw. It is difficult to accept the view that the chin has been modified in form to facilitate the productions of articulate sounds. Normally variations or fluctuations in the size of the teeth or dental arches tend to take place *en masse*. Among the civilized men of today there is observable a reduction in the size of the teeth, and this feature is generally beneficial. It is an illustration of a relatively rapid evolution to meet the altered requirements of the civilized environment, etc. In addition to its morphological parts, the book includes much sensible discussion on vitamins, hormones, and the causation of dental and jaw abnormalities. The illustrations are very good throughout. They include as a special and rare feature, a series of casts of a very nearly perfect denture developed by a son of the author under the latter's guidance as to food and the use of the jaws." (*American Journal of Physical Anthropology*, October-December 1927).

Several points in my book give interpretations of certain questions differing materially from those originally held by Sir Arthur Keith. I ventured to criticize adversely several of his observations and opinions, yet, in the following extract from his fairly long review of my book in *Man* (November, 1927, pp. 210-212), it may be seen that he appreciates criticism, like all good scientists, which may be helpful to the full elucidation of the subject.

"At present we are using methods which are too crude to bring out and express the precise manner in which races differ in form of face We have to found such methods on a full knowledge of how the face grows and the exact part which each structure of the face plays in the physiology as a whole. Therein lies the value of this work by Dr. Sim Wallace: it deals with the growth of the case and the part which the muscles of mastication play in its development . . . He gives new data; the exact measurements made on the growing jaws of his son from infancy to full adult years are valuable but it is rather to his observations, to his opinions and to his experience, that his work, which was deservedly awarded the Cartright Prize, owes its chief attraction. Were full justice to be done to his book this review would have to make too serious an inroad on the space available in this journal."

The cause of caries depends chiefly on the lodgability, fermentability, viscosity and impermeability of food with regard to acids and alkalies, while the irregularities of the teeth are caused chiefly from conditions arising from interference with growth and the natural instinct to gnaw in infancy, resulting from depriving children in early life more especially of those foods which tend to throw pressure strains on the growing jaws. Yet the prevention of both may be coordinated, as the proper consistency of food and associated stimulating principles are very useful in preventing caries, while this same consistency of food is similarly satisfactory in supplying the liberating stimuli of pressure strains.

Here it may be mentioned that the administration of cod-liver oil or other vitamin concentrates is quite unnecessary to insure the proper development of the jaws. Indeed since writing my "Recent Medical and Dental Research on Diet and Accessory Food Factors in Relation to the Prevention of the Diseases of the Teeth," the fact that the administration of cod-liver oil is by no means an invariably safe proceeding is becoming increasingly clear (*British Medical Journal,* August 24, 1929). The research work on this subject seems to have been undertaken by Scandinavian investigators and published in the *Acta-Poediatrica.* Even cautious therapeutic doses are explicitly stated to produce distinct changes when the administration is continued for months, and as Dr. Rolf Hallgren points out "most disquieting is the observation that the experimental animals gain weight and appear to be healthy in spite of severe organic lesions, found only at autopsy" (*Public Health,* February, 1929). And he concludes by saying that on no account should the doses recommended in current pharmacological textbooks be given during any considerable length of time.

As the action of cod-liver oil "has been studied in a series of animals—calves, pigs, cats, dogs and rodents—and has been found to be fairly uniform," and as a fatal case of hypervitaminosis D was recorded in a child by Dr. Lewis Thatcher in 1931[7], it would seem wise to call a halt to the wholesale advocacy of cod-liver oil, vitamin D, or various forms of irradiated milk. It would never be necessary even to anticipate the occurrence of rickets if proper food and environment are available, and certainly from the prophylactic point of view it would be far more rational to point out the dangers of a rachitogenic diet and environment than to use as a prophylactic a drug such as irradiated ergosterol, even though it be curative as regards rickets. It should also be realized that it is by no means clear that rickets is a deficiency disease, as at least with an apparently normal supply of foods containing this substance but supplemented by an excess of rachitogenic food—e.g., unsuitable carbohydrates, the disease may eventuate. It should, too, be realized that a deficiency of what cures is not necessarily the cause of the disease. Perhaps most important of all, it is not wise to initiate or impose a system of prophylaxis depending upon drugs in infancy, childhood or other ages, or advocate any medicine whether it be for the teeth, bones, brain, or anything else. The routine advocacy of drugs in child welfare centers is a most retrograde step. Surely it must by this time be realized that hygiene and public health are, or should be, based on biological principles and not on preventive medicines. The contention in my first book which attracted the greatest attention was that the extraordinary prevalence of caries, irregularities of the teeth, faulty and insufficient growth of the jaws, together with associated diseases arising from oral malhygiene, could all be prevented by simple attention to diet based on an appreciation of the natural hygienic processes which man, in common with other mammals, possesses.

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# Chapter V

## OBSERVATIONS, DISCUSSIONS AND PROGRESS

In a general way it may be said that the attitude of the dental profession in the last decade of the nineteenth century towards the problem of the prevention of dental caries and the maintenance of oral hygiene may be indicated by the following quotations: "The fact that decay of the teeth is of parasitic origin having been once established, the thought suggests itself that we ought to be able by means of properly chosen antiseptic materials, not only to arrest decay, but also to prevent its appearance. This is indeed the avowed object of the very many antiseptic mouth washes now on the market. As a matter of fact, however, there is no evidence that anything has as yet been accomplished in the prophylactic treatment of the teeth through the use of antiseptic mouth washes."[1]

Research workers in the dental profession were for many years working on the wrong track. Indeed so long ago as 1900 I noted that: "The mouth has never in the history of man or animal been an aseptic chamber, and paradoxical as it may seem, and contrary to all recent ideas relative to methods for the combating of caries, I will affirm that under proper dietetic conditions the bacteria of the mouth are valuable agents in the preservation of the teeth. The mouth bacteria give rise to the continual disintegration and the removal of the protective mucous coating supplied by the buccal secretions. It is difficult to imagine a better method for the prevention of caries at those places where the friction of fibrous food cannot dislodge all inherent matter, for while the mucous coating protects the necks of the teeth the bacteria provide a means for the removal of all accumulations of debris, whether it be decomposing food or incipient tartar deposit."[2]

Naturally when thinking over the subject with regard to the cause and prevention of the diseases of the teeth, it seemed to me that the diet of our simian ancestors suggested a new line of thought based on biological principles, which offered a rational solution. The outlines of this I have indicated in the previous chapters and in my first book.[3]

Of course parents who had infant children were reluctant to begin experimenting with their own children. There were, however, some few, highly distinguished authorities, who appreciated the reasonableness of the system advocated, which after all the discussion was noted by J. H. Mummery when he said that the diet I recommended "does not depart to any great extent from that adopted by most sensible parents and should be strictly adhered to."[3]

It is, however, not altogether easy for those who do not know the rationale of the natural method to carry it out successfully when dietetic habits are formed and if surrounded by temptation to depart from it. Moreover when conflicting advice and erroneous notions are being broadcast, the less informed are liable to be confused and distracted. A brief reference to the results revealed show that it is certainly not so difficult as it might at first sight appear, and that the dental profession is right in acclaiming it not only as the best method but also the most physiological, natural and agreeable when commenced sufficiently early in life.

Though the evidence upon which it was originally based is more than forty years old, it was not until 1914 that the first results of its being put into practice were published. I was then able to record that "Fourteen children have been subjected to this test, and at ages ranging from five to seven years their teeth were examined with the result that not one tooth of any of these children showed the slightest trace of caries.[4]" This may not seem a large number, but when we remember that in England a similar number of the same class would certainly have had eighty or ninety carious teeth among them at the same age, we see that according to this alone there is overwhelming probability or practical proof that the theory is correct.

Following this, a number of dentists recorded similar results with regard to children under their care, or known to them to have been brought up on the natural or physiological regime.[5]

Investigations have more recently been made into the conditions of the teeth in institutions in which the dietary resembled that which had been shown in individual cases to have given such excellent results. I have referred to some of these already. In certain cases such a regime was deliberately planned, omitting the caries-inducing foods and including the more effective detergent foods, as in the case of the more recent research of Bunting and his collaborators. Other examples might be given in which, though not deliberately planned, the truth of the theory is similarly shown. Thus, S. Dunn, Senior Dentist, Glasgow Education Authority, found that in most institutional schools, dental decay, tartar and infected gums were prevalent in those institutions where the dietary was rich in soft starchy foods and deficient in the more cleansing fibrous varieties. But he says, "In visiting the Langside School for the Deaf for a number of years, I cannot recollect any mouths in the condition just described. I have made inquiries in the routine of the diet, and found that the clean mouths were wholly attributable to the Sim Wallace doctrines being unconsciously carried out—a good quantity of fibrous foods requiring at dinner a knife and fork and fresh fruit daily at the end of each meal. I find at other places, even when meat is given, it is minced and all partaken with a spoon; milk puddings a frequent item in the menu, but no fruit to follow, except rarely."[6] In the foregoing and other references which might be given, we have striking confirmation of what is "now the generally accepted conclusion." Further the theory has been confirmed on a large scale and independent of institutional control. Professor Middleton Shaw referred recently to the subject saying, "This view of caries is not only held by a majority of the dental profession but in England has been officially endorsed by the Society of Medical Officers of Health. In the county of Shropshire these views were so strongly held by the late Dr. James Wheatley, School Medical Officer, that as far back as 1910, he decided to give them practical effect by lecturing to the medical profession, teachers and nurses in this area on dietetics. The results obtained were nothing short of amazing. In ten years he was able to record an increase in the number of school entrants with perfect teeth from 5 per cent to 44.4 per cent. During the years 1910-1914 he and his colleagues examined the teeth of 37,527 children and found that at the age of five, the number of carious teeth per child was 6.4; the percentage free from caries 5.0. At the age of twelve the corresponding percentages were 4.6 and 2.9. During the year 1919 and the first three months of 1920, 10,593 more children were examined. In 1919 at the age of five, the number of carious teeth per child was 2.1; and the percentage free from caries was 42.0. The corresponding figures for 1920 were 1.9 and 49.0. At the age of twelve a similar improvement was found."[7] In passing it should be noted that Wheatley's recommendations were enforced to a large extent by war conditions, more especially the restrictions on the consumption of sugar, sweets and artificially sweetened foods generally.

No doubt largely due to the extraordinary success of this dietetic regime, the Society of Medical Officers of Health officially endorsed our views (1923). This society, naturally desirous of bringing what was known to the attention of those immediately concerned, drew up in leaflet form a few simple rules for the use of parents and those interested in the welfare of children. The leaflet is also endorsed and issued by The People's League of Health and the Dental Board of Victoria.

Though not in leaflet form, the Dental Board of the United Kingdom authorized the publication of an address by the chairman, Sir Francis D. Acland. This, in addition to being published, was reproduced in the form of a gramophone record by the International Educational Society. In it, with regard to diet and eating he said: "Teeth must have exercise particularly when the jaw is growing. A little child with only four teeth should be given hard crusts of wholemeal bread to chew now and then. From childhood onward, no one should ever end up a meal with anything that leaves a sticky paste on the teeth; like cake, buns, pastry, or sweets. As to sweets, a doctor went the other day to one of the islands of the Hebrides, and gave lectures on the care of the teeth in the schools, and he found the only place where the children's teeth were bad was a village where there was a sweet shop. Finish a meal with oatcake or wholemeal bread with plenty of butter, or better still with fruit or uncooked vegetables, such as lettuce—and apple is best of all. Never, never, should a child have a biscuit or anything else when it has gone to bed for the night."[8] Observations such as these from distinguished authorities were liberal, gratifying and so encouraging that another interesting phase of the subject may not be amiss.

In 1933, Mrs. Lilian Lindsay, M.D.S., vice-president of the Historical Section of The Royal Society of Medicine and president of the British Dental Association published *A Short History of Dentistry,* and in a paragraph dealing with the progress of "The Prevention of Dental Disease" wrote that, "At the international Medical Congress in 1881, Arthur Underwood and W. J. Milles communicated the result of their investigations into the effects of organisms upon the teeth and alveolar portions of the jaws; this was the first bacteriological attempt to discover the bacillus of dental caries. W. D. Miller, of Berlin, extended and confirmed these researches and published in 1884, his theory, which has since been known as the chemical-parasitic theory of dental caries. In 1839 William Robertson, of Birmingham, suggested that sticky food remaining upon the occlusal and interstitial surfaces of the teeth produced decay at these places, and Magitot, in Paris, had given a thesis on dental caries in 1867 in which he investigated the effect not only of food but also of saliva on this condition. For centuries it had been held popularly and in the writings of dentists that sugar and sweetmeats destroyed the teeth. A. Tolver, in 1752, wrote a whole chapter on the bad effect of 'second courses' and this chapter was faithfully copied by Berdmore, who agreed with Tolver that the prevalence of dental disease among the Dutch was due to their inordinate love of sugar and confections. At the Congress in 1881, mentioned above, J. R. Mummery, who had already made a study of the teeth of all races, ancient and modern, sent out a questionnaire, as a result of which he hoped to record useful data on the cause of dental caries; the only answer he received was, however, one dealing with the personal experience of a dentist upon his own teeth, which showed that the ideas upon sticky carbohydrates had some foundation. Meditation upon these facts and publications of Miller, led J. Sim Wallace, in 1889, to put forward the first of a long series of articles dealing with the effect of diet upon the teeth and jaws and to formulate a regimen introducing in the daily diet those foods which, by their fibrous and sapid nature, would encourage the flow of saliva, and, by the exercise of the muscles of mastication, stimulate growth of the jaws, and at the same time have a detergent effect upon the teeth and gums. This was the first scientific effort at the prevention of dental caries, disease of the gums and irregularities of the teeth."[9] What follows in future chapters may indicate the success or otherwise of my effort.

In an address entitled "Can Caries be Prevented on the Lines Laid Down by Dr. Sim Wallace? Evidences from Actual Experience,"[10] Mrs. Lilian Lindsay said: "Prevention of dental caries, like the philosopher's stone, the elixir of life, or Eldorado, has been sought by men of varying degrees and wisdom from the dawn of history. Prevention rather than treatment was the method by which man believed that such a disfigurement and disablement as the loss of teeth inflicted upon him could be avoided." She supported my views as magnanimously as any one could wish for but it is the appreciation of others to which I would call special attention here.

The president, in opening the discussion, paid tribute to her "very able and well-considered paper," but he only mentioned one concrete case of a dentist who in answer to a questionnaire sent out in 1881 by Mummery said that "For a long period his diet had been simple, with practically no variation, during which his teeth remained in good condition. A time came when his diet was altered, became more complex with an increase in more readily fermentable carbohydrates, and the result was a rapid onset of caries. This will no doubt coincide with the clinical experience of many of us.

"The next speaker, Mr. L. C. Broughton-Head, thanked Mrs. Lindsay for bringing so practical a subject before the society. He supposed that all the members present more or less agreed that the diet, usually associated with Dr. Sim Wallace's name, was to be regarded as the most useful and practical method of combating dental caries, especially in children and adolescents. He thought that the greatest offenders in this respect were the house-masters and house-mistresses of the boarding schools, both preparatory and public—where the dietary, so far as his inquiries from young patients extending over many years disclosed, remained unchanged and was little, if any, influenced by modern views on dietetics. The three principle meals still finished with starchy and sticky foods; and fresh fruit, if any, was available only once a day, and usually eaten at mid-morning break."[10]

In the discussion of her communication, "Mr. Sanderson said that he was very pleased to have heard Mrs. Lindsay's paper on Dr. Sim Wallace's theories, and he was very pleased to have this opportunity of paying a tribute to the work of Dr. Wallace, which was brought to his notice over twenty years ago by Dr. H. J. Gibbs. He had taken an active interest in the work and had got many of his patients to arrange their meals in accordance with the rules laid down and the results were very striking. He was convinced that if the rules were carried out, caries would be decreased by about 70% . . . Surely a test like this is, from a dental point of view, of more value than experiments in the feeding of puppies or rats. He had also Dr. Wallace to thank that his own two children had no caries in their teeth at the ages of twenty and sixteen, and that in spite of the fact that their teeth were never brushed before the age of seven or eight. The theories were not difficult to carry out, and he was convinced that if they were adopted, not only the teeth, but the health of the children would benefit."[10]

Previous to this date Mr. J. H. Gibbs, F.R.C.S., L.D.S., late Dental Surgeon to the King in Scotland; Dental Examiner, R.G.S. Edin., said in the *Edinburgh Medical Journal*, 1917; "Of great interest to us who are seeking the solution of the problem of dental caries in the children of the masses, is the fact that a sufficiently large number of children have been brought up on the lines laid down by Sim Wallace to prove that, under modern civilised conditions, dental caries can easily be entirely prevented or almost entirely prevented."

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# Chapter VI

## DENTAL CARIES. DISCUSSIONS AND RECENT PROGRESS

Before attempting to give an epitome of our present day knowledge with regard to the prevention of the irregularities and diseases of the teeth, it may be recalled that in 1873 the second edition of the most widely read work of its time on Dental Surgery was published.[1] Therein we find a description of dental caries and a fuller discussion of the whole subject has been added in the form of an appendix, in which a summary of the conclusions to be drawn from previous investigations will be found.[2]

The description of dental caries is no doubt of interest to dental surgeons but the prevention of the diseases of the teeth together with the correlated charm of facial beauty is of extreme importance to all, or at least to those who have suffered from the cruel pain of dental caries and concomitant diseases or from the disfiguration of the face which so frequently results from insufficient or deranged development of the jaws and crowded irregular or other unsightly arrangement of the teeth.

The modern developments in the prevention of dental diseases and our knowledge of the developmental stimuli required for the completion of the growth of the bone depend largely on the recognition of the Newer Knowledge of Hygiene in Diet based on Physiological principles. The advances in surgical and mechanical dentistry are rather secondary adjuncts of oral hygiene but the PREVENTION of dental diseases has been the aim and ideal of some few benevolent dentists. Unfortunately the artificial aids they invoked have achieved but little success. Nevertheless correlated branches of biology have, during the last half of the 19th century, given us the data upon which our present day knowledge is based.

The Messrs. Tomes in 1873 do not seem to have put much importance on the use of a toothbrush, and antiseptic mouth washes had at that time never been suggested. It was maintained by them, however, that dental "caries is an effect of external causes, in which so called 'vital' forces play no part . . ." and that "when once the disintegrating process is established at some congenitally defective point, the accumulation of food and the secretions in the cavity will intensify the mischief by supplying fresh quantities of acid".

They stress the importance of heredity by saying:

"There can be no question that the tendency to caries, whether induced by structural deficiencies or perverted functions, is strongly inherited."[1]

The work of Magitot, G. V. Black and W. D. Miller, largely inspired by L. Pasteur's investigations on fermentation brought noticeable advances in our knowledge of the chemico-parasitical nature of caries, but no solution was made of the *Problem of Dental Caries* with regard to the cause or causes of its increasing prevalence. Degeneration of the structure of the teeth resulting from malnutrition and insufficient use was incriminated all to no useful purpose. This idea gave rise to apathy, reliance on toothbrush drill and antiseptic mouth washes, together with the activities of dental surgeons and mechanics.

What the state of our knowledge was in the decade preceding 1900, may best be recalled by alluding to the fact that the alarming prevalence of dental caries naturally led to an extraordinary interest being taken in the discovery of the causes and the best method of prevention of the disease. This may well be indicated by directing attention to a discussion which appeared in *Nature* in 1894. The subject at that time was apparently thought to be complex and etiological questions are not always easy to set at rest. Much work has been done, and many hypotheses were propounded, but, unfortunately the results of the investigators have not infrequently carried absolutely no conviction whatever. Indeed, so much was this the case that dentists were slighted for being unable to give a satisfactory explanation.

The following extracts from the discussion referred to give clear indications of the views held by learned disputants in the early years of the last decade of the 19th Century.

Mr. Ebbles says:

"Now it has never been proven that the increasing prevalence of caries is due to weakness of the teeth, owing to comparative disuse, but there is nevertheless, great probability in the inference, especially as signs of wear and freedom from caries appear to occur together and vice versa. There is, however, a further point in regard to the existing liability to attacks of caries, which, I think, can best be explained by a transference of nourishment to other parts governed by the same nerves."[2]

Mr. J. H. Mummery, probably the most learned dentist in England at the time followed, saying

"It is difficult, however, to understand how nerve strain can have any direct effect upon fully formed teeth, and we should, I think, look for the explanation of the cases referred to in some vital condition of the fluids of the mouth, caused by depressed condition of health, so common amongst hospital nurses.

"There is little doubt that an open air life and healthy surroundings encourage the formation of sound teeth in a sound body; but I cannot but think that the principal cause of caries must be looked for in the food. . . . Structural defects, due to inherited weakness or imperfect nutrition during the development of the teeth, combined with the use of soft cooked food, which is long retained in contact with them, and is of a nature eminently suitable for fermentation give us, I think, the principal factors of decay amongst civilized races.

"While allowing the influence of nerve strain in early childhood, and, as a factor in hereditary transmission of defective structure, I fail to see how it can influence teeth already formed".[3]

Re people in the north isles of Scotland—Mr. Wenyon observed that

"We find here side by side old people with strong teeth free from decay, though possibly worn down like those of an old horse, and several generations later among whom dental caries is quite general and including many girls in their teens who are almost edentulous.

"The habits of the older and younger generations form an equally striking contrast. The former, even as children were thinly dressed, and did well on three meals daily. Both men and women gathered seaweed for kelp in all weathers, and worked until the tough bannock in their pockets became a tempting meal".[4]

According to Mr. W. G. Black, however,

"The most likely medium of teeth caries, however, being induced is the use of hot drinks; soups, tea and coffee, which primarily may cause a fissure in the enamel by unequal contraction and expansion in the structures of the teeth. Into this fissure on cooling down, will be kneaded by mastication, articles of irritating food and drink which will lead to caries around it".[5]

and may be more critically examined.

The next letter on this subject in *"Nature"* is from Mr. C. S. Tomes,

He begins with a sweeping indictment on all the previous writers, saying

"None of the writers of the interesting letters which have appeared upon this subject seem to have kept before them a distinction which is of the utmost importance". This seems a somewhat strange reflection on the letters of the able and lucid writers to *"Nature";* but the unfortunate part about Mr. Tomes' letter is that he fails to point out that the distinction is of the utmost importance—in fact, he only shows that there is no importance in the distinction at all.

He says: "Dental caries is very prevalent, and its increase seems to be very rapid, so that the last few generations show a marked increase—at least, so it is generally believed. But its victims may be divided into two groups—namely, those whose teeth are apparently perfect in their construction, but nevertheless fall prey to caries, and those whose teeth show to trained eye clear evidence of structural weakness".

Here we have "the distinction which is of the utmost importance", and what does it amount to? Only this, that the two classes of teeth referred to fall a prey to caries. Now it is difficult to see the utmost importance of this distinction. After some remarks on heredity, Mr. Tomes attempts to describe the class of teeth which show clear evidence of structural weakness. He approaches the subject as follows: "But it is quite common to meet with instances of healthy parents with good teeth having a family of children, also apparently healthy and well grown, whose teeth, although to the casual observer normal in shape, size and general aspect are, to the eye of the dentist doomed to early destruction and speedily undergo it. These teeth have an appearance somewhat difficult to describe: they have a glassy look, are more translucent than they should be, are softer, and are believed, though the proof is not complete, to be somewhat deficient in lime salts".

Mr. Tomes is not, apparently, content with first throwing cold water on the previous writers and confusing the question with invisible important distinctions and more confusion on heredity, but he gives them the final douche by informing them that

"there is a considerable amount of literature on the subject which seems to have escaped them", and also mentioning that

"the question, interesting and important as it is, is not so simple a matter as some of your correspondents would imagine".

Some few years later Dr. G. V. Black, a highly distinguished member of the dental profession in America, strongly urged the eludication of this subject. Shortly after this Mr. Storer Bennett earnestly appealed to the younger members of the dental profession to direct their attention to this matter. In his presidential address to the Odontological Society he said:

"There will always be those who will need the dentist's services, and in time to come we shall find that prevention is better than cure; for rest assured of this, the mystery of immunity will be unravelled by someone, and it is my earnest hope that the discovery will be made in England.

"It has been reserved for us dentists in the closing years of the nineteenth century to show what dental caries is, and how it is produced. Is it then, too much to hope that the earlier years of the twentieth century—nay, I would even say the opening year—may also reveal to one of us the means of its prevention? Or are we in the future to sorrowfully admit that this, the greatest discovery of all, has been made by one who is not a dental practitioner?"

Let us now proceed to a discussion which appeared in the *Lancet* in 1900. It commenced with a criticism of my first book, and reads as follows:

"In a recent publication Dr. Sim Wallace has advanced an ingenious theory to account for the increasing prevalence of dental caries. His views are as follows: 'The cause of the prevalence of dental caries is that the natural foodstuffs are to a large extent ridded of their accompanying fibrous parts and prepared and consumed in a manner which renders them liable to lodge and undergo acid fermentation in the mouth, while from this same cause and the induced conditions the micro-organisms of the mouth lodge and multiply and augment the rapidity and intensity of the acid fermentation'. That the preparation of our foodstuffs may in some small measure assist in the production of caries seems possible, but that it is 'the cause' is highly improbable. Much of Dr. Wallace's reasoning is unsound, and many of his statements are incorrect. He crosses arms with those investigators who maintain that the teeth are degenerating in some unknown way, and so are unable to resist the action of the acids set up by fermentation in the mouth. He prefers to hold the view that the cause is to be found in the foodstuffs being prepared in a manner which makes them more apt to lodge in the mouth, and he makes the statement, quite unsupported by any data, that 'the teeth of the present day are as perfectly formed from a chemical and microscopical point of view as are the teeth of those races which are practically free from caries'. That the structure of the tooth plays a most important part in the resistance to caries is within the knowledge of a dental practitioner with even a small experience. For example, in mouths where there is but a slight amount of caries, and that slow, the enamel of the teeth is generally hard and resistant to the instrument, while where caries is prevalent and rapid the reverse is the case. Indeed, it requires but little observation to show that there is something, so far not recognized or understood, which plays a most important part in the liability of teeth to be attacked by caries. Crowding of the teeth is a fruitful predisposing cause of caries and this is acknowledged by Dr. Wallace, but he attributes the crowding to want of development of the tongue from lack of fibrous material in the foodstuffs. The removal of this fibrous material from the foodstuffs robs the tongue of a certain amount of activity, and so interferes with its development. Here again, as with nearly all his statements, no data are given in support of his contentions. The true cause of caries has yet to be discovered, and is not quite so simple as Dr. Wallace would lead us to believe".

By way of reply to this criticism, we may quote a letter which followed from Dr. Harry Campbell:

"Dr. J. Sim Wallace holds that the great prevalence of dental caries among civilized peoples is due to their eating soft and pappy foods requiring little mastication. Some years ago you were good enough to publish in the *Lancet* a letter from me, in which I urged the same view. My interest in the subject led me to read Dr. Wallace's work carefully directly it appeared, and I hope I may be permitted to say that I was greatly impressed by the closeness of his arguments and the scientific spirit pervading his book.

"My original contention was that soft foods predispose to caries by leading to imperfect mastication, and thus to defective nutrition and development of the teeth; and although I still venture to think that this may be a factor, Dr. Wallace has converted me to his views that soft foods lead to caries essentially by modifying the buccal environment of the teeth,

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the teeth being no longer properly cleansed by coarse fibrous foods, the buccal secretions being no longer adequately excited, and so forth.

"Regarding Dr. Wallace's remarks as to the toothbrush not being altogether an unmixed blessing, it is significant that the very next day after reading them there consulted me a man, aged twenty-two years, who had never in his life used a toothbrush, and he had thirty-two sound teeth in his head.

"I feel convinced that if Dr. Wallace's views are taken to heart by the medical profession, we shall do much to diminish caries and other defects of the teeth. I, indeed, believe with him that we have it in our power to rear a race having teeth every bit as good as those of our primitive ancestors".

Sometime after this the following letter from Mr. Berlyn then appeared:

"In the *Lancet* of July 14 (p. 134) to hand by this last mail, I notice a letter from Dr. Harry Campbell, in which he supports the theory of Dr. J. Sim Wallace that 'the great prevalence of dental caries among civilized people is due to their eating soft and pappy foods requiring little mastication'. Would either of these gentlemen kindly explain how they reconcile this theory with the following fact? The great majority of South African natives live on nothing but soft pappy food, which consists of a very soft porridge made from ground mealies or Indian corn. Their only method of cleansing their teeth is to fill the mouth with water and rub the teeth with the finger. And yet carious teeth among natives are the exception rather than the rule; on the contrary, they possess beautiful, sound, strong, milky-white teeth, of perfect shape and formation, absolutely free from any taint of tartar or other discoloration, and seldom, if ever, malformed or irregular."

This elicited the following replies from Dr. Harry Campbell and myself:

"If Mr. A. Berlyn's assertion be correct that 'the great majority of South African natives live on nothing but soft pappy food, and if it can be shown that they do not habitually chew hard things of any kind, then the view I hold, in common with Dr. J. Sim Wallace, falls to the ground. That, however, these natives do use their muscles of mastication far more than civilized peoples seems to me to be proved by the perfect development of their jaws and muscles of mastication. Nothing is more certain than if these structures are not adequately used they will not develop properly.

"In the *Lancet* of August 25 I notice that Mr. Berlyn, of Cape Town, would like explained how the fact which he put forward could be reconciled with the theory I advanced and which was so generously supported by Dr. Harry Campbell. Mr. Berlyn says: 'The great majority of South African natives live on nothing but soft pappy food which consists of a very soft porridge made from ground mealies or Indian corn . . . and yet carious teeth among natives are the exception rather than the rule'. I should like to point out that this porridge is made of Indian corn which is bruised or crushed, and there is no attempt made to eliminate the coarse and fibrous part such as is done by the elaborate processes which wheat, for example, undergoes in the manufacture of flour. As far, therefore, as this, the staple article of diet, is concerned, the Kaffir does not eliminate the fibrous part from natural foodstuff. According to my views, such a food is not liable to lodge in the crevices of, and between, the teeth, and the fact of masticating it tends to keep the teeth free from fermentable matter. I bruised and crushed some Indian corn, first with a hammer and then with pestle and mortar, after having soaked it in water for twenty-four hours so as to try to make it soft. I then boiled it for an hour. On examining, I found the more or less powdered part mixed with a fine tough, transparent scale, which naturally surrounds the corn grains. I then added a little salt, and ate the porridge thus prepared. It required a very considerable amount of mastication, much more than does coarse brown bread.

"I think, however, Mr. Berlyn is hardly correct in saying that the majority of the natives 'live on nothing but soft pappy food', as the following extract from Ratzel's 'History of Mankind' (vol. ii. p. 433) would indicate: 'Thus the Kaffir gets his food about equally from his fields and from his herds. The basis of it is sour milk (amasi), and bruised maize (amabele), or millet (umbla). Meat is eaten alike boiled or roast, and is much relished by the natives. According to Gardiner's estimate, four or five can manage to eat up a whole ox—entrails, sinews, and all—in a day and a half'. The teeth are often much worn from the very considerable amount of mastication which they perform, and, as will be observed from their eating the sinews of an ox, they are not particularly addicted to eliminating the fibrous part from their foodstuffs. These people are very free from dental caries, and are an interesting confirmation of the theory that 'the cause of the prevalence of dental caries is that the natural foodstuffs (of the civilized), are, to a large extent, ridded of their accompanying fibrous parts, and prepared and consumed in a manner which renders them liable to lodge and undergo acid fermentation in the mouth' etc."

Several other letters on this subject appeared in the *Lancet,* but I shall only allude to Dr. T. G. Read's view, which, in the form they now take, appear to support my contention that the prevalence of dental caries is due to the fact that food is "prepared . . . in a manner which renders it liable to . . . undergo acid fermentation in the mouth."

It may be well now to refer to certain observations which appear to have largely misdirected the attention of observers on this subject.

Dr. Miller says:

"The structure of the teeth plays the most important part as a predisposing cause of dental caries. Poorly developed, soft, porous teeth, with many large interglobular spaces, are highly predisposed to caries. As a lump of table salt dissolves more rapidly in water on account of its porosity than an equally large piece of rock salt, porous dentine is more rapidly decalcified than well-developed, firm dentine, because the acid may the more readily penetrate the tissue, and because less acid is required to decalcify a porous than a hard tooth".

I disagree with Dr. Miller, more especially in his interpretation of the causes of the structural defects and deterioration in teeth which he assumes to exist. He says:

> "There can be no doubt that a deterioration of the teeth accompanies the progress of civilization. The reasons for it are many. The mode of life of most uncivilized races not only conditions a sound, well-developed body, but the osseous system, of course, including the teeth, show the same vigorous development, and, above all, a compact structure. An individual whose youth is spent in the open air, unrestricted in his bodily freedom, is likely to possess a body better developed in all its parts than one who has been brought up in a modern schoolroom.
>
> "The quality of the food also exerts an influence on the teeth not to be underrated. They form no exception to the rule that an unused member will be less perfectly developed than one constantly used.
>
> "The pressure brought to bear upon the teeth by mastication causes a more lively circulation in the periosteum and in the pulp, thereby inducing an increased deposit of lime-salts or a more complete calcification. Practical experience also teaches that children brought up on soft food (broths, paps, etc.) generally have bad teeth. If a race of human beings or of animals were to make no use of their teeth for several generations, we should expect to find a gradual deterioration of the dental structure. It is, to say the least, highly probable that the soft quality of many of our foods as compared to those of uncivilized races, conditions a soft, porous, dental substance, as well as an imperfect development of the jawbone, and a concomitant crowded position of the teeth".[6]

Let us consider the points above quoted seriatim. With regard to the general mode of life of savages conditioning a sound, well-developed body and the bones and teeth showing a compact structure, this may be wholly doubted, for the general mode of life of savages is usually less hygienic and less conducive to general good development of body, and, indeed, for physical endurance the savage is usually not equal to the civilized.

It is true that an individual whose youth is spent in the open air, unrestricted in his bodily freedom, is likely to possess a body better developed in all its parts than one who has been brought up in a modern schoolroom, but this is because functional activity is necessary to the complete development of the muscles and body generally. The development of the teeth is totally independent of this functional activity—indeed, the vulnerable part of the crown is invariably formed before the tooth has cut the gum, and before the child has reached the modern schoolroom. They thus do form an exception to the rule, that an unused member will be less perfectly developed than one constantly used. Moreover, assuming that the pressure and strain of mastication did cause a more lively circulation of the blood in the periosteum and pulp, and on that account induced an increased deposit of lime-salts, this could have absolutely no effect upon the enamel, which is an inorganic substance formed once for all in early childhood. Caries commences in the enamel, and if the enamel is once disintegrated, the ultimate destruction of the tooth is almost inevitable unless operative measures are taken to prevent it. That children who are brought up on broths, paps, etc., generally have bad teeth, or rather, carious teeth, is true, but this arises from a different cause than Dr. Miller would have us believe. It arises from the fact that foods requiring much mastication have a detergent action, while soft, nonfibrous food not requiring much matication is very liable to lodge in the crevices and between the teeth. This point is of importance, for, according to my theory, the eating of fine biscuits and hard sweets may help to induce caries, whereas according to Dr. Miller's contentions, such hard food ought to give rise to compact structure of the teeth, and ability to resist caries.

Lastly, Dr. Miller's contention that the diminished use of the teeth and jaws should be expected to give rise to a gradual deterioration of the dental structure is not in accordance with present day biological teaching, and moreover the belief is disheartening and pernicious, for if such were the case the hope of regaining the normal excellence of our teeth could only be a remote one, instead of being within the immediate power of every intelligent parent.

There is no doubt that a persistent belief in the inheritance of acquired characters, and in the modification by disuse through successive generations is at the root of our long continued belief in the inherent degeneracy of teeth at the present day. This belief has absolutely prevented the correct interpretation of the causation of caries, for if caries is assumed to be hereditary an explanation must be made which elicits the cause acting through the individual, and through reproductive cells. Until quite recently it was supposed to originate through the teeth—i.e. through some defective structure of the teeth, and perhaps this is still the prevalent belief. However, Dr. Black has shown that at least the relative amounts of lime-salts in teeth supposed to be susceptible to caries, and in teeth which are not supposed to be susceptible to caries, can no longer be held to be the reason for "susceptibility" and "immunity" to dental caries. The dominant idea of hereditary transmission of the disease has, however, apparently led Dr. Black into the equally extraordinary idea that the transmissibility of the disease is via the oral secretions. I admit that had it not been for an unswerving belief in the non-transmissibility of acquired characters I should never have arrived at my own conclusions. The apparent hereditability of the disease is almost overwhelming, and the apparent diminution in size of the jaws from relative disuse through successive generations has made it be selected as a good example to illustrate the tenets of those who believe in the hereditary transmission of acquired characters (e.g. Herbert Spencer).

If the hereditary nature of the disease is believed in, of course the investigation of the qualities of foodstuffs is an almost profitless investigation; if, however, the Neo-Darwinian doctrines of heredity are believed, it becomes an almost self-evident corollary that it is in the chemico-physical nature of the food with regard to dental hygiene that we must seek for the cause of the prevalence of caries.

The next set of beliefs which seem to have misdirected attention are those originating from a recognition of the parasitical nature of dental caries. Immediately it was proved that dental caries was caused by bacteria the whole dental world rose in arms against the bacteria of the mouth. Antiseptics of all kinds and strengths were used in the hope of exterminating the micro-organisms. It never dawned on anyone that the bacteria of the mouth might, under proper dietetic conditions be "valuable agents in the preservation of the teeth"[7] or that under normal conditions the use of antiseptic mouthwashes is to be deprecated. When I advanced these views a few years ago, I knew I was going straight in face of what was considered established fact, but in a recent discussion in the *Lancet* Dr. Harry Campbell has ably championed my theory, and Dr. Miller in his recent experiments, while perhaps not going quite so far, has at least furnished us with material which tends very strongly to confirm the position which I originally took up.

This is indeed particularly strong evidence in favor of my views, for up to this time (1900), Dr. Miller was the arch-champion of the antiseptic or bactericidal method of preventing caries.

In 1901 the verdict of the authorities in the University of Glasgow who had to decide on the merits of my first book are summed up in the letters, D.Sc.

In the following description of the act of mastication taken from Huxley's *Elementary Physiology*, there seems to be an incompleteness if not an error. It runs:

> "When solid food is taken into the mouth it is cut and ground by the teeth, the fragments which ooze out upon the outer side of their crowns being pushed beneath them again by the muscular contractions of the cheeks and lips; while those that escape on the inner side are thrust back by the tongue until the whole is thoroughly rubbed down . . . When the food is sufficiently ground, it is collected, enveloped in saliva, into a mass

or bolus which rests upon the back of the tongue, and is carried backwards to the aperture which leads into the pharynx."

It will be observed that this description would lead one to think that the food is comminuted, mixed with saliva, and made into bolus form and then swallowed. What actually takes place is very different. Firstly, however, it must be noted that certain foodstuffs which are consumed at the present day are hardly subjected to the process of mastication at all. The food is simply taken into the mouth, receives a general squash between the teeth or between the dorsum of the tongue and the hard palate, and is then swallowed. This method of mastication—if mastication it can be called—is, as a rule, adopted for custards, fine meal porridge, soft puddings, and soft nonfibrous foods generally.

When there is a certain amount of firm fibrillar matter in the foodstuff, then the process is essentially different, and mastication is performed in a more thorough manner. In this latter case, the food is crushed and torn between and heaped on to the masticating surfaces of the teeth by the muscular contractions of the tongue, cheeks, lips, and motions of the lower jaw. During comminution between the teeth, the juices of the foodstuffs, the saliva which becomes incorporated,[6] and the suspended nonfibrous part, are pressed out from the fibers and gradually collect during the process on the middle of the dorsum of the tongue, which is gradually hollowed out for the reception of such foods, and this part is then swallowed. The fibrous part of the food, however, is subjected again and again, to crushing and disintegration between the teeth. If any of the fibrous part passes towards the back of the dorsum of the tongue, it is arrested by the pressure of the anterior part of the tongue against the rugæ of the palate, and while the fluid and finely comminuted part gets sucked or pressed back into the hollow formed at the back of the dorsum of the tongue, the coarse and fibrous parts are thrown between the teeth and subjected again to the crushing, squeezing, and comminution. The rough surface of the tip and dorsum of the tongue and the smooth-ridged palate are especially well adapted for this separation of the food prepared for swallowing, and that which requires further mastication.

If careful note be taken of this process, therefore, it will be found that the food is not, as a rule, formed into a bolus and then swallowed, but that the bolus is continually slipping away to the dorsum of the tongue to be swallowed till there is no bolus left at all.

The recognition of this, which I consider the essential nature of the process of mastication, is of great importance, for as I have pointed out elsewhere,[7] the effect of chewing food of a more or less fibrillar nature tends to dislodge the fine particles of foodstuffs which otherwise are apt to lodge between and in the crevices of the teeth, and then give rise to dental caries.

At the present day there is a positive craze for the elimination of firm fibrillar matter from the foodstuffs, and thus to a certain extent real mastication can be but imperfectly performed, and its beneficent effects are almost wholly lost.

It is well known that the lodging of food particles (especially carbohydrates) in the mouth is liable to bring about caries of the teeth, and if the chemical nature of the fibrous part of the food, even that taken from the vegetable kingdom, be taken into consideration, it will be observed to be less amylaceous or saccharine than is the nonfibrous part.

There are other ways in which the masticating of fibrous food is beneficial. Not only are the teeth kept cleaner than a toothbrush can keep them, but the salivary and buccal secretions are more thoroughly stimulated, the deposit of tartar and the recession of the gums are prevented, and the tongue when required to perform the requisite motions during the process of thorough mastication develops more fully, and brings about a more regular set of teeth than can possibly be had if the tongue is not well-developed. Finally the stomach and intestines are supplied with that more or less innutritious matter and stimulating principles which are so necessary for the healthy performance of their functions.

Meanwhile the advance of bacteriology and the important investigations of Dr. Miller had established definitely the exact nature of caries. Miller's work seemed to lend some support to the popular idea that sugar was harmful to the teeth; but, unfortunately, he confined his considerations almost wholly to the chemical differences in food, and thus such well-known facts as, for example, that native children who consume large quantities of sugar from sugar cane seemed to remain immune, proof that this was not a cause of the prevalence of caries of any consequence.

Miller also records experiments indicating variable susceptibility of different teeth to the action of acid, just as ordinary table salt is more easily dissolved than rock salt, thus appearing to confirm the hypothesis that there is a molecular difference in the constitution of teeth, which would explain more or less varying susceptibility. Miller also indicates his adherence to the idea that acquired characters may be transmitted,[8] and in the hereditary predisposition[8] to the disease, although if I am not mistaken he places less importance on the hereditary and constitutional nature of the disease than do other authorities.

Next to the erroneous beliefs with regard to heredity the idea which has been most potent in preventing the solution of the question of susceptibility and immunity was the discovery of the direct or exciting cause of caries, namely, acids and micro-organisms, for immediately this was demonstrated it was but natural to think that immunity would be secured by the more or less complete destruction of the micro-organisms. Under the sway of this theory antiseptic mouth washes, tooth soaps, and tooth powders have been introduced, and elaborate investigations made of the antiseptics which are most powerful in destroying the micro-organisms of the mouth, while bactericidal properties have been searched for in every possible constituent of the saliva or of the secretions which are poured into the mouth. How thoroughly past research has diverted investigators from any guidance in the search of the cause of immunity may be gathered from Dr. Miller's recent communications[9] and negative results.

I do not mean to depreciate the excellent work of the authors to which I have referred, but only to point out that together with the good there was always in my opinion something which prevented thought and investigation from settling on the true solution of "susceptibility" and "immunity."

Fortunately the progress of biology during the 19th century, the newer ideas of A. R. Wallace with his theory of the "Survival of the Fittest" supported by Darwin's very similar views on Natural Selection, together with the advance in knowledge in bacteriology, biochemistry, anthropology, dietetics and the principles of oral and alimentary hygiene furnished a basis upon which a rational and effective theory of prevention of dental caries, irregularities of the teeth and pyorrhea could be easily and securely established.

The abandonment of the belief in the hereditary degeneration of the teeth and the misleading idea that acquired characters from want of use were inherited aided us in formulating rules of prevention now generally accepted by the leaders of thought in the dental profession as well as by medical officers of health and some physicians who have come to recognize the importance of hygiene in diet.

Before the end of the last century it was generally considered that the all important requisite of food was that it should be nourishing and easily digested. Food-stuffs were primarily classified according to their chemical properties.

We may now review the knowledge which it has been considered desirable to teach dental students with regard to "the Classification of Foods and the function of Elimination" since 1900. Firstly we observe that food-stuffs are classified under four heads, (1) proteins, (2) fats, (3) carbohydrates, (4) salts, (mineral matter) and water.[10] Huxley also gives an

Elementary Exposition on the Composition and Action of Saliva; emphasizing the action of a small quantity of a peculiar substance called ptyalin which has certain very remarkable properties.[10]

Unfortunately "very little is known of the chemical nature of enzymes, but they are strongly characterized by certain facts as the conditions under which their action takes place. Thus: (1) Very minute quantities will effect a change in the mass of the substance on which they are working, which is enormously large compared with the minute mass of the enzyme. (2) Their action depends closely on temperature. At 0°C (32°F.) they cease to act; as the temperature rises they become increasingly active, and are most active at about 40°C. (104°F). At higher temperatures they become less active and lose their powers permanently if once heated to 100°C. (212°F) as by boiling they are then said to be "killed. (3) Their action in many cases depends on the reaction, whether alkaline or acid or neutral, of the solution in which they are at work. (4) Their action stops in the presence of an excess of the special products of their activity, and (5) it has not so far been conclusively proved that the enzymes are themselves used up during the changes which they produce on other substances".[10]

The foregoing is all very interesting to physiologists but it throws very little light on the reason why there has been such an astounding increase in the prevalence of caries together with the progress of civilization which has in many ways been conducive to the welfare of humanity. Why should the triumphs of civilization and hygiene give rise to better health and longevity while at the same time the diseases of the teeth have become the most prevalent of all diseases? Does it not suggest that all the intricacies of physiology have distracted our attention from the fact that the hygiene of the mouth and teeth together with the stimuli necessary for an adequate secretion of saliva at the proper time as well as the stimuli for the development of the jaws, have been neglected. Perhaps this may have resulted from the peculiar idea that milk should be regarded as an ideal food for children even after they are weaned. No mammal on earth is brought up on such a foodstuff which is the most pernicious carrier of disease in common use. Why should we risk it? Why not direct attention to the food we eat and relish while at the same time we might acquire tastes suited to the welfare of civilized man. The anatomy of a child's mouth from birth onwards, as also the physiology and instincts, may teach a mother far more about the best way to bring up a child than the most excellent and well equipped physiological laboratory or dissecting room. However, do take note of what can be seen or felt and try to imagine the nature of the mouth of the suckling before it is five or six months old. It may then be interesting to observe the coming into position of the incisors. What we can see and feel in a child's mouth may guide and indicate the physical nature of the food for which it has been adapted for countless generations. Why direct or misdirect attention to the complex chemical composition of milk, and distract attention from the physical nature of the gums. When the infant is a few months old, consider the light which the very remarkable properties of the *enamel* covering of the teeth suggest with regard to the physical consistency of the food the child should take into its hand to experiment with it as instinct suggests, and then consider the very important detergent properties of a crust, or other form of food which is so frequently destroyed by soaking in milk and administered with a spoon. These things interest the mother but their significance with regard to food and feeding may not be known to her. She probably does not realize the development of the muscles of mastication including the tongue can be influenced just as can be the muscles of a blacksmith's arm. Similarly the chemical formulas of enzymes are of infinitely little use for the child, the mother or the nurse. Neither are they likely to see the significance of the fact that no animal before the advent of the Zoological Gardens, ever soaked its food in milk.

Huxley continues with all the general information usually given to medical students, but omits all that is necessary for maintaining oral and alimentary hygiene. To the lay reader it is rather complicated and difficult for the family doctor to explain in such a way as to have any effect on the formation of proper dietetic habits during the eruption of the temporary teeth. Simplicity in classification of foods for those interested, and instruction supported by an infant's instincts are certainly desirable. Nevertheless all that is primarily required to be taught is that "the food of children should be of a chemical composition such as is found in mothers' milk . . . but the physical characters of the solid food should diverge from that of milk in proportion to the number of the teeth erupted, that is, it should be the opposite of that currently advocated.[11]

It seems to me that dilating on the "very remarkable properties" of ptyalin in saliva, and regarding the secretion of the salivary glands as primarily for the digestion of starch is misleading, as its chief function is almost entirely for the maintenance of oral hygiene. The saliva together with the mucus it contains "is important as a lubricant and, a vehicle for dissolving and removal of food particles. It lubricates the mucous membrane and teeth on the one hand and the food on the other, thus facilitating the passage of the food from one part of the mouth to another during mastication, and finally ensuring its complete, or practically complete, removal from the buccal cavity. The mucus is secreted in amounts proportionate to the requirements of the particular kinds of foods for these purposes. Likewise the saliva facilitates the same physiological processes and the quality and quantity secreted is also proportionate to the requirements of the food consumed. Saliva has also a marked effect in preventing acids taken in food or developed by bacteria from decalcifying the enamel, and this effect seems to be much greater than could be accounted for simply by its power of neutralizing the acid. Mucus is freely miscible with saliva, so that even if mucus has no similar power of protecting the enamel from decalcification it does not hinder such beneficent action of the saliva. The variations in the amount and the quality of the saliva and mucus corresponding to the quality of the food consumed appear to be common to all, whether "susceptible" or "immune" to caries. That this is so is not a subject of controversy, but nevertheless the fact that the normal physiological processess supply with marvelous ingenuity the means of securing the cleanliness of the mouth and teeth seems to be persistently overlooked by many who believe that the mouth is clean, or otherwise according to whether it has or has not been brushed with a toothbrush".[12]

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# Chapter VII

## DIETETIC THEORIES

There are at present several different dietetic theories relating to the cause and the prevalence of dental caries; one element, however, is common to all of them, namely, that the change brought about by modern processes for preparing and refining food is answerable for the prevalance of the disease. It is maintained by some that the removal of the husk from the grain, for example, impoverishes the amount of bone forming salts, phosphates, etc.; by others, that the removal of the husk diminishes the amount the jaws are required to be used and deleteriously affects the blood supply and consequent nutrition of the teeth. By still others, the refinement of the foods is claimed to be the cause of the foodstuffs and bacteria being especially lodgeable in the crevices of and between the teeth, etc. It is not my intention to enter into a discussion on the relative merits of the different views, suffice it here to say that if we maintain that the elimination of the coarse and fibrous elements, e. g., the husks of the grain, the skins of fruit, the tough parts of meat, etc., is harmful to the teeth, we are bound to consider whether the supposed advantages gained for the stomach and economy in general by such refinement are of more importance than the deleterious effect upon the teeth.

It may seem very surprising to maintain that the refined foods which are prepared with all care should be conducive to such havoc in the teeth while that very refinement appears to be necessary for the stomach. I frequently tell my patients that they must give up feeding their children on refined foods, and am generally met with the rejoiner that the stomach is of much more importance than the teeth. With children's specialists, too, a like idea prevails. They appear to think that in general the feeding of children, as advocated in current textbooks, is as nearly correct as is necessary for all general purposes. This, however, I believe to be an erroneous idea.

It is a general law that animals, when subjected to any particular environment, become in the course of generations adapted to that environment or die, and that having become adapted to the environment, acquire a hereditary structure which tends to continue indefinitely till impressed forces or change of environment changes that hereditary structure. It follows that animals are adapted to that environment under which they have lived for countless generations, and are not adapted to a changed environment when such is forced upon them.

To descend now from the general principle to the case in hand. The ancestors of present day man, savages, Simian progenitors, etc., lived a life which necessitated their living largely on natural foods selected with an instinct which apparently showed no mean regard for their animal economy. The environment remained practically the same from one generation to another, and the hereditary structure became eminently adapted to this environment. As regards these foods, they were much the same as the natural foods are today before they are subjected to processes of elaborate refinement and cookery. The hereditary structure, according to biological principles, still survives, if not in its entirety yet in a great part. That we are structurally unfitted to the new foods is amply manifested by the fact that about 95 per cent of us are well equipped with carious teeth and a similar percentage are troubled with chronic or occasional indigestion. It is generally recognized that carious teeth and dyspepsia are among the most common afflictions to which man is subject. We know that prehistoric man had relatively excellent teeth, and we also know that Nature would have made short work of him had he been crippled with dyspepsia. We know, moreover, that in their natural environment savages and anthropoids are rarely subject to dyspepsia.

Along very different lines knowledge was accumulating, which I believe points in other and more profitable directions. The Neo-Darwinians had shown that acquired characteristics were not transmitted, and thus to them the idea of the hereditary degeneracy of teeth collapsed. Those who adopted this Neo-Darwinian view say at once that Black's investigations into the calcification of teeth only confirmed their deductions, and I, at least, saw no reason for the prevalent carping criticisms and the attempt at molecular disintegration of the facts which he brought to light. Further deductions from the belief that acquired characteristics are not transmitted lead me to ignore the assumption that "hereditary predisposition to caries is the first importance."[1]

Despite the tide of opinion among dental surgeons and the weight of authority which supported it, I came to the conclusion that we had been drifting in the wrong direction and that a dietetic solution of the problem was the only one possible. I further affirmed,

"that under proper dietetic conditions the bacteria of the mouth are valuable agents in the preservation of the teeth."

It could hardly be expected that views such as these would be readily accepted at the time they were first published (1900), but though they have now met with very considerable approval, further amplification and justification of the theory almost seems to be called for.

Surely it is evident that when a child is brought up on foods of a consistency demanding real mastication, as has been indicated, it acquires the habit of masticating whereas pap-fed children do not acquire the habit so thoroughly. Leaving aside other considerations which tend to make certain people masticate efficiently, it should be observed that the act of mastication is most important in the natural self-cleansing of the mouth. When it is efficiently performed, the ptyalin gets thoroughly incorporated with the food, and converts the starch into a soluble form, which becomes expressed from the bolus and swallowed; or if a little lodges about the teeth, the constant rushing of the saliva between and about the teeth tends to dislodge or dissolve any starchy matter that might otherwise lodge and undergo acid fermentation. Thus with efficient mastication it is not only the exposed surfaces of the teeth which the saliva helps to clean, but even the most inaccessible crevices. It should be remembered too, that the mastication of food which demands considerable muscular activity calls forth a corresponding flow of saliva, and no doubt the continued use of food causing a healthy flow of saliva tends to develop the salivary glands. Thus again those who habitually consume food stimulating the flow of saliva are both directly and indirectly less susceptible to dental caries.

Another general effect of coarse food and efficient mastication, is to wear the cusps of the teeth so that the crevices become small or obliterated, and consequently the susceptibility of food to lodge is lessened.

The modern refinement and preparation of food makes particles which lodge about the teeth peculiarly nonirritating. If the food is highly refined, "short", and soft, it may be plastered into the crevices of and between the teeth after meals without stimulating saliva, or exciting the tongue to dislodge it, but if, for example, nuts are consumed there is something in their physical nature which makes one very conscious of their presence and stimulates not only the flow of saliva, but also the motions of the tongue and cheeks until they ultimately are dislodged.

The modern preparation of food also tends to deprive it of the natural fresh vegetable acids which would otherwise almost invariably accompany vegetable foods. Thus it correspondingly happens that the saliva is not so fully stimulated as it should be. Now when acid is taken into the mouth not only is the saliva stimulated directly, but the acid which reaches the stomach stimulates the flow of saliva also. The importance of what we may call the after-flow can hardly be doubted. For the frequent swallowing which it causes after meals is a most potent factor in the self-cleansing of the mouth.

In a paper appearing in *Dental Record* in June 1913, Dr. F. D. Boyd, Physician to the Royal Infirmary, Edinburgh, was able to demonstrate in a very conclusive way that digestion was performed in a much more satisfactory manner when the consistency of the meal was of such a nature that mastication had to be performed. Thus:

"On two days the patients got the same amount of food: ¾ lbs. meat, 10 oz. bread, and 100 grm. Contrastin. On the first day the food was very finely subdivided and swallowed as a mush mass. The peristaltic waves occurred in one patient in 1 minute, 35 seconds, in the second in 1 minute, 25 seconds. On the second day the same food was taken as grilled steak and toast; in each patient there were ten peristaltic waves in 35 seconds. The one meal was mushy, the other required chewing; the constituents were the same, the influence on gastric peristalsis was pronounced. With the mushy meal the stomach turned almost paralysed, while with the meal which required chewing a considerable part was found in the duodenum when the meal was finished. Following the food down the alimentary canal, we found that with the mushy food the colon contained little at the end of six hours, while the food which was chewed was well on in the transverse colon in the same time; most of the delay took place in the stomach.[2] The x-ray photographs showed that when a soft pulpy meal had been consumed, the stomach after six hours contained a considerable quantity of the meal, a certain amount having reached the lower end of the small intestine, while six hours after the chewed meal had been eaten by the same patient the stomach was absolutely empty and the entire meal had reached the colon, passing as far as the splenic flexure."[2]

Here then we see certain current inferences derived from the experimentalist's glass bottle stomachs completely reversed and we observe, quite independently of considerations having to do with the teeth, that food should not in general be presented to children which does not demand subdivision in the mouth.

I shall now refer to an observation which can scarcely be doubted, namely, that on the whole people who eat three meals daily are less susceptible to caries than those who eat a greater number daily. The explanation of this is I believe as follows: When only three meals are consumed the stomach is generally allowed to empty itself before another meal is taken so that the process of digestion goes on normally. During the consumption of one of these meals there is a considerable flow of saliva, for the appetite tends to be keen and the secretion fairly abundant. After the meal is finished the afterflow of saliva continues for a time but gradually decreases as the acid secreted by the stomach gradually increases. Suppose on the other hand, that four or five meals are taken daily then the stimulation of the flow of saliva is unduly divided and the amount secreted during and immediately after is less when three meals are consumed.

Let us now direct attention to the method of the self-cleansing process. If the food has been of such a nature that real or thorough mastication has been called forth, then of necessity any particles of food that do lodge will be well incorporated with saliva, and as the ptyalin does not exhaust itself appreciably, the process of the conversion of starch into a soluble form will continue so long as the starch remains. The afterflow of saliva from the parotid passes round the buccal sides of the teeth, and is sucked in between the teeth each time the act of deglutition occurs. Thus any food particles tend to be dislodged and swallowed. With some people the mouth seems to be callous, and the particles of highly refined food do not materially stimulate this self-cleansing process, but with others the case is different, and after meals they may be observed swallowing frequently and may, unfortunately, sometimes be heard sucking the saliva between their teeth evidently semiconsciously dislodging food particles. With each act of deglutition too, the floor of the mouth is brought upwards and the tongue pressed forcibly on to teeth and palate, while part of the saliva from the sublingual and submaxillary glands is forced out between the teeth. Then again the tongue performs certain movements which tend to dislodge food particles. It may be pushed out over the molar teeth, and the point bent upwards or downwards between the cheek and the gum and then carried forward or it may otherwise be thrust between the teeth and the cheek or lips and made to dislodge particles of food.

There are certain conditions which influence this self-cleansing process, for example, the arrangement of the teeth. I have shown elsewhere[3] that the arrangement of the teeth is chiefly influenced by dietitic considerations, but what I would here refer to is that the natural movements of the jaws during mastication are frequently prevented by the malocclusion of the teeth. It often happens that the occlusion is of such a nature that the lateral or grinding movements are prevented. Now this grinding movement is of importance especially for the self-cleaning of the molar teeth, for the more the lateral movement the more is the saliva pressed and sucked to and fro between the approximal surfaces of the molar teeth. We shall have occasion to refer again to the arrangement of the teeth in elucidating susceptibility and immunity of the different teeth.

Another condition of some little importance in the self-cleaning process is the mucous coating over the teeth. In every mouth there are parts of the teeth which are not naturally subjected to much mechanical cleansing, and these parts are consequently liable to lodge food particles. They are more or less protected by a thin slippery film which adheres to the teeth so firmly that if the tongue is swept over it, it is not removed. If the particles of food lodge on the surface of this film, the self-cleansing motion of the lips, cheeks, and tongue tend to dislodge them. Similarly the removal of the particles of food by the tongue from the mucous membrane of other parts of the buccal cavity is no doubt facilitated by the slippery nature of the mucous membrane.

In conjunction with the variable nature of the salivary secretion, due to the difference in chemical and physical properties of the food, we should note the difference in quantity of the mucous secretion. If the food is of a bland, soft nature, the mucous secretion is not stimulated much, but if it is coarse and fibrous the mucous secretion is considerably stimulated. The nature of the mucus should be considered. It clings tenaciously to the surfaces with which it comes in contact, and it coats the teeth where they are not subjected to friction. Being of an albuminous nature it does not induce the acid-forming bacteria to proliferate, while if the food is acid it becomes insoluble and forms a more or less impassable barrier for the acid. After the meal, however, the alkaline saliva—in which it is soluble—tends to clean it away, together with adherent food particles.

We may now consider the nature of the micro-organisms of the mouth. Some are acid producers, some are liquefacient, and some produce acid or liquefy according to the medium in which they exist. It is obvious that those bacteria which liquefy gelatine and other albuminoid substances must be of great importance in rendering shreds of foodstuffs soluble and thereby helping to clean the buccal cavity, and within limits the acid producers may have a similar function. In fact, it would seem impossible to do without the mouth bacteria, as there is no ferment in the mouth capable of digesting the albuminous shreds and particles which otherwise would be bound to accumulate between and about the teeth.[4] It may be said that at least it would be well to do without a considerable proportion of the acid producing bacteria, for without acid it is impossible to have dental caries, and no doubt this is true. But this result is best obtained by efficient mastication, for food which requires considerable mastications calls forth a corresponding flow of saliva which becomes thoroughly incorporated with the food. The ptyalin converts the starch into a soluble form, while the mastication expresses it from the rest of the bolus. Thus the starchy matter is more or less thoroughly swallowed, while the remaining part is being more completely masticated. By this means the smallest possible residue tends to lodge about the teeth, and what little does remain, being almost devoid of starch, allows the bacteria which liquefy to predominate while preventing the multiplication of the acid-preducing bacteria. If, however, food—especially starchy food—is taken in a soft form the flow of saliva is related to the amount of starch, but inefficiently stimulated. The starch is not fully converted and swallowed but remains plastered, as it were, into all the crevices in and about the teeth. Furthermore, the chronic lack of efficient stimulation of the salivary glands engendered by relatively soft foods leads, no doubt, to a corresponding lack of development and output of ptyalin. Now if there is a relatively great amount of starch left about the teeth, can we wonder that the acid producing bacteria largely preponderate and play havoc with the teeth?

There are some clinical observations which tend further to corroborate these observations, for example, the fact that millers, who are constantly breathing flour dust, are particularly susceptible to caries, while on the other hand those who suffer from chronic gingivitis due to tartar, tend to show signs of immunity to the disease. In the first case we have a constant supply of carbohydrates without the physiological processes which clear them from the mouth, and a consequent increase in the number and intensity of the acid-producing bacteria, while on the other hand the chronic inflammation of the gums at the necks of the teeth give rise to an undue proliferation of albuminous epithelial and other cells and a consequent increase in number of the liquefying bacteria. Presumably also the inflammation produces an increased flow of the alkaline secretion which is normally produced at the necks of the teeth.[5]

"This at least may be assumed to take place in the early stages of the structures around the necks of the teeth."

"The question of the different susceptibilities of different teeth to caries still remains an unsolved problem."[6]

If, therefore, we can show that the known susceptibilities of the various teeth conform to and are the result of the conditions which we have explained with relation to susceptibility to caries in general, then not only will the solution of an unsolved problem be an interesting addition to our knowledge but it will be an argument of considerable importance in establishing the truth of the general contention which we have already advanced. We now enter upon a problem which obviously does not necessitate us making further reference to the nature of the food. We have now to deal solely with the conditions which permit of the lodgment of fermentable food where "susceptibility" is known to exist, while we have to show these teeth or parts of teeth which show "immunity" are subject to those self-cleansing processes already described.

We should remember the direct effect of mastication; the indirect effects of mastication, i. e., the muscular contractions of the tongue, cheeks and lips and the influence of those on the fluids of the mouth; and the effect of ptyalin in dissolving the carbohydrates and thus facilitating the removal by swallowing of the converted starch.

Let us first direct our attention to the lower incisors and canines. These teeth are peculiarly "immune" to caries. Their shape is such as to render the lodging of food practically impossible except on their approximal surfaces, for not only are there no crevices on which food might lodge but the motions of the lower lip and tongue are greater, over the labial and lingual surfaces than over any other teeth. Leaving other things out of account at present, the fact that the mandible and the tongue are relatively fixed posteriorly the greater susceptibility for food to lodge must be towards the back of the mouth. So too for similar reasons the saliva is caused to pass between anterior teeth more fully than it does towards the back of the mouth.

Then again, when a piece of food is cut by the incisors the lingual surface of the superior incisors acts as a buttress upon which the food is held while the lower teeth cut through it. While the lower incisors are passing through the food, the food is gliding down over the labial and lingual surfaces of the teeth thus keeping them clean. So that even though the lower incisors are irregular through crowding, the rubbing past of the food, while it is being incised prevents as a rule a great tendency for the food to lodge and undergo fermentation. In this we see a remarkable difference from the upper incisors, for as the lingual surfaces of upper incisors act as a buttress to the food a certain amount is squeezed between them and therefore the approximal surfaces of the upper incisors are liable to lodge food which may undergo acid fermentation. The incisors are unlike other teeth in that when they are slightly spaced they are not so susceptible to caries as molars and bicuspids. This follows as a natural corollary from the fact that they do not bite the food down to the gum and leave it to lodge there. Each act of mastication tends to force it out from between the upper incisors while the motions of the lips and tongue render it well-nigh impossible for food to lodge between the lower incisors when they are spaced.

When there is crowding of the upper incisors the tendency of food to be jammed between the teeth is great, and consequently the tendency to caries is very considerably increased.

There are frequently pits and crevices on the lingual surfaces of the upper incisor teeth, and these of course tend to have food jammed into them, and consequently to become carious.

The canine teeth are particularly insusceptible to caries, and if their shape is considered it can hardly be wondered at. We may here illustrate an interesting detail. Though the shape of the tooth may in itself be of such a nature that food does not tend to lodge about it, yet the approximal teeth may have considerable effect in modifying this. It very frequently happens that the first upper bicuspid decays on its mesial surface from the lodging of food, but of course, this same food lodges against the distal side of the canine. We consequently expect, and almost invariably find, that there is approximal decay on both teeth. However, it should be noted that the tooth presenting the broadest and flattest approximal surface (the bicuspid) is the most liable to be most affected, and, moreover that the decay is most diffused. This naturally follows as the fluids passing between the teeth become, as it were, focused in passing over the more rounded tooth and exert their beneficient influence while the food tends to lie on the flattened part of the bicuspids. The usual channel for the saliva, therefore, is closest to the most rounded tooth and thus it may escape the destructive action of the acid fermentation altogether.

Passing now to the bicuspids, it need only be remarked that they are intermediate in size, shape, and position to the rest of the teeth, and are therefore intermediate in their susceptibility. Interstitial caries is fairly common, and the crevices between the cusps give rise to a susceptibility such as would be expected from the principles already brought forward.

The first permanent molar is particularly susceptible to caries for the first few years after it cuts the gum, and its susceptibility to be attacked rapidly declines after about the eleventh year. In fact, if it has not been attacked before the child enters its teens, it shows but little special susceptibility to caries at all. This may seem a curious and almost inexplicable problem, but I think it resolves itself quite easily. Firstly, it should be remembered that the natural crevices are well marked, and the breadth of the tooth keeps the tongue and cheeks well away from the crevices and approximal parts midway between the lingual and buccal surfaces. This of course does not help much to explain the special susceptibility of the tooth to decay in the early years of its existence, but yet it allows of a mal-environment being easily produced. Secondly, it should be remembered that during the first six years after eruption it is the hindmost tooth in the mouth, and the motions of the cheeks and tongue are relatively not very pronounced in its neighborhood. Thirdly, in the earliest years of its existence the habit of mastication upon it has not been acquired. Nor is there any special demand for more masticating surface than the temporary molars afford. At least there is no special demand for it if relatively soft food is consumed. Fourthly, the circumstance which hinders the child acquiring the habit of masticating efficiently, and consequently of acquiring the beneficial results of efficient mastication, is the fact that the temporary teeth begin to be shed just after the eruption of the first permanent molar, and their looseness or tenderness tends to prevent the child masticating as efficiently as it would otherwise. Fifthly, the fact that by this time the temporary teeth are frequently carious and tender very frequently leads the child into habits which only remotely resemble efficient mastication. Lastly, during this age sweets are frequently consumed too freely.

I need not now go into much detail with regard to the second and third molars; the only special fact which we need refer to is the rapid and frequent destruction of the wisdom teeth. Here we need only remember the circumstances already referred to, namely, the position towards the back of the mouth and the very lengthy period which usually elapses between the cutting of the cusps of the tooth and its rising to its position of full functional activity.

How little the intrinsic nature of the tooth itself has to do with the question of predisposition to caries may be gathered from the fact that if the teeth in front of it have been removed so that it erupts normally and easily the wisdom tooth seems, even in "susceptible" mouths to be fairly "immune",* provided it occludes properly with its fellow above or below.

After the first discussion in the *Lancet* in 1900 on the subject, my object was to indicate the nature of the causation of the irregularities of the teeth without assuming that they resulted hereditarily from want of use for some few generations, i. e., without assuming the inheritance of acquired characteristics, though this delinquency of Nature was assumed by Sir Charles Towes and many, if not all, exponents of the subject at that time. Moreover previous writers had generally recognized that irregularities of the teeth came about as the result of deficient growth of the mandible and maxillae. Here, however, I shall only refer to Sir Frank Colyer's comment where he refers to Dr. Harry Campbell's observations on the "Influence of Mastication on the Jaws" concluding with the statement:

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* I have used the words "susceptibility" and "immunity" in these essays though I do not believe that the use of these words in relation to dental caries is strictly accurate. There is little or nothing corresponding or analgous to the conditions which produce susceptibility and immunity to specific diseases.

"Existing races that live on coarse food requiring abundant mastication invariably have well-developed jaws. Referring to my opinion with regard to the part played by the tongue, Colyer says: 'The tongue influences the position occupied by the teeth in the arch', and records that in my 'opinion the under-development of the tongue and the decreased size of the jaws at the present day are to be attributed to the slight amount of mastication which is now necessary in the consumption of food'. Colyer also generously notes that 'a lucid account of Dr. Sim Wallace's views is to be found in his work on the *Irregularities of the Teeth*.'[7]

"A year later my views on this subject were referred to as generously by the President of the British Society for the Study of Orthodontics. In his presidential address he spoke of 'three epochs in the science of orthodontics', and with regard to my views he recalled the meeting at which I originally brought forward my views and referring to me said, 'He had seized and emphasized facts of enormous importance, and though he was laughed at at the meeting, he has lived to see the truth and other truths he has brought before the profession widely adopted.'"[8]

Other scientists, such as Sir Arthur Thomson, showed gratifying appreciation of my views.[9] Even more encouraging was Dr. Alexis Hrdlicka, the world famous anthropologist and curator, Physical Anthropology Division, Smithsonian Institute, Washington, D. C.[10] I might also give laudatory references to my work on *The Irregularities of the Teeth,* from highly distinguished orthodontists in America, notably E. H. Angle, *Malocclusion of the Teeth,* 7th Ed. p. 113, Lisches, B. E., Prof of Orthodontics, Washington University Dental School in the introduction to the *Principles and Methods of Orthodontics*, 1912, p. 22, and to Geo. W. Grieve, Toronto,[11] who said that he was "heartily in accord with me", and felt that "my" book, *Variations in the Form of the Jaws,* would sooner or later, be recognized as one of the most outstanding contributions to the subject up to this time.[12]

It may be said I have recorded too many laudatory references to my views, but many research workers like myself appreciate honest appreciation and enjoy it. Moreover it stimulates others to write for or against the arguments and facts brought forward. Furthermore as was noted in a review of my book, *The Irregularities of the Teeth*:

> "To those dentists who—puzzled by the phenomena they daily witness—desire to consider causes, this work will well pay perusal. Some of us are even putting his theories into practice. Dr. Wallace . . . is combative, and is never happier than when tilting at certain accepted theories enshrined in the textbooks . . ."[13]

generally regarded as authoritative in England.

With regard to rational ideas in the prevention of dental caries by artificial means, we can record remarkable progress. Many important series of articles in the *Lancet,*[14] Dr. Harry Campbell concluded by referring to and supporting my views with regard to the value, or otherwise, of the toothbrush, tooth powders, and antiseptic mouth washes. He said:

> "The modern toothbrush requires to be used with great caution, as it is capable of doing much harm, not only by removing the mucoid film—which according to Dr. Wallace, protects the teeth from corroding agencies—but probably also by injuring the edge of the gum and the neck of the teeth and thus setting up the condition known as 'erosion' ".

Dr. Campbell referred also to the harmful effects of antiseptics, and was even more emphatic in condemning their use than I had been. Mr. Hopewell-Smith referred to these "iconoclastic" statements and said: "Ask 100 per cent of the members of the dental profession to name the two great remedies against the initial commencement of caries of the teeth, and all with one voice will exclaim: (1) The use of the toothbrush; and (2) the use of antiseptic mouth washes." Yet Dr. Campbell's statements—at least, with regard to the protective coating— seemed to have impressed Mr. Hopewell-Smith favorably; and, further he remarked that he was "quite dissatisfied with the usual textbook explanations of the etiology of dental caries."[15]

Commenting on the discussion which ensued on Dr. Campbell's observations in the *Lancet*[16], the Dental Annual and Directory for the following year said that:

> "Little or nothing has been added to our knowledge of the phenomena of dental caries in the scientific literature of the year, but some amusement and interest has been aroused by iconclastic opinions ventilated in medical periodicals as to the efficacy of tooth powders and the artificial operation of brushing the teeth and gums. There has been a remarkable consensus of opinion as to the superiority of early mastication, the use of hard and resisting food, and the general exercises of the jaw muscles, with the increased vascular and nervous supply resulting as compared with soft feeding and artificial cleansing."[17]

It would appear that we shall soon have to regard the procedure of brushing the teeth rather in the light of a cosmetic, than as of any particular value in preventing caries. This view, indeed, has been expressed in the *British Medical Journal*[18] and more recently in a leading article in the *British Journal of Dental Science*[19], which says:

> "We have all observed mouths free from caries where no efforts at 'oral hygiene' have ever been made, and we are all familiar with mouths requiring constant dental attention, the owners of which are zealous in the use of the toothbrush and dentifrices. In fact with respect to the toothbrush, we are of the opinion that its use is more of a cosmetic than of a prophylactic nature, though we by no means condemn its use as a means to prevent caries."

Lest misapprehension should arise, it may perhaps be advisable to say that it is not my intention to condemn the toothbrush in toto, but only to relegate its use to a quite subsidiary position. I think its use may perhaps be advocated under most dietetic conditions which at present prevail during childhood; and those who are willing to take the trouble may be encouraged to do so, with special restrictions when there is recession of the gums or erosion cavities. Its use, unlike rational methods of feeding, however, cannot be depended upon solely to prevent caries, irregularities of the teeth, deposits of tartar, or recession of the gums and loosening of the teeth in later life. Nor can its use be depended upon to remove calcific deposits when the normal coating of the teeth is so fully impregnated with lime salts as to form tartar; in fact, when the teeth have a pathological coating, there is practically only one wise course open to the patient, and that is to go to the dentist and have it thoroughly, and, if necessary, repeatedly removed, and the accompanying pathological states properly treated.

The evidence which tells against any special reliance on the toothbrush and antiseptics is now greater than when my contention was first made, for at that time no one had confirmed my contention with regard to the beneficient role of the mouth bacteria.

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# Chapter VIII

## DIET, REFINEMENT OF FOOD, IRREGULARITIES OF THE TEETH

At first my method of investigation was merely to ask patients, whose teeth were irregular or ravaged by decay, what they ate, in order to find which foods were the most harmful. I, then, made hypotheses that such and such foods were bad and asked especially about those. I found that though some of my hypotheses were wrong some apparently were fairly correct. I pursued this method for years and in a general way seemed to have a fairly good idea of what foods were or were not harmful. I, then, made several experiments on the lodgeability of foodstuffs, and found that the foodstuffs which perhaps might have been expected to lodge did not, and *vice versa*. It was not until about two years ago that I observed it was not so much any particular foodstuff which seemed to induce caries as the elimination of the fibrous part and its destruction by most methods of cookery. I had, in fact, been searching for about seven years for something injurious *in* the food, and had not observed that the *absence* of the fibrous part (which cleans the teeth during mastication) was a very considerable factor in the causation of the disease.[1]

"In writing about the causes of a disease such as dental caries, one is continually conscious that the ultimate object is the prevention of the disease." In this chapter, however, I intend treating of the prevention of dental caries in order to direct attention to the causes from a different point of view, and to advance further arguments in support of the conclusions as to the cause of its prevalence, for "only by varied iteration can alien conclusions be forced upon reluctant minds." The reader may almost surmise the method of prevention which is about to be advocated. It is that the diet of civilized man must be altered in order to suit the physiological requirements of the teeth, but before entering upon this subject it is necessary to discuss some psychological considerations. It is quite useless to advocate something which is antagonistic to the instincts and desires of the great majority; we know that although men are perfectly alive to the fact that certain conduct, e.g., intemperance, will bring about certain results, and though those results may be more harmful and painful than those brought about by caries, if the desire for the alcoholic stimulant be considerable it is folly to advocate a method of treatment which does not take into account a consideration of this desire and its probable results.

For some time past it has been recognized and insisted upon that beneficial results to the teeth are certain to accrue from the constant use of the toothbrush, but we know that this method of keeping the teeth in good order is not resorted to by the great majority of those who will readily admit that its use night and morning would save them a considerable amount of pain and anxiety on coming to the dentist. Even dentists themselves who are daily insisting that patients brush their teeth are frequently delinquents in this matter, and since this is so, we need hardly wonder that children sometimes forget the use of the toothbrush. This method of preserving the teeth has been insisted on for some considerable time, and yet caries is on the increase, and that too among the very class in which the benefit from such a procedure is conscientiously believed in. I think that this method has had a fair trial, and that, partly perhaps from the impossibility of getting people to do it, and partly from other reasons, it is futile to expect from this means alone any substantial change for the better in the condition of the teeth.

If I advocate that the fibrous matter which accompanies the carbohydrates in their natural state should not be eliminated, or if eliminated that it should be consumed together with or followed by some foodstuff which is detergent, e.g. meat, fish and vegetables, the question arises, would people do this, even though they were thoroughly persuaded that it would prevent decay in their teeth? Even the most sanguine who have had, for example, to advocate dieting patients for dyspepsia, might despair of this method. Nor can we be altogether hopeful that mothers would change the food of their children, and bring it into accord with the physiological requirements of the teeth. Still, there is a numerous and increasing class of women who do make some attempt to acquaint themselves with the principles of hygiene and dietetics, and bring up their families accordingly. Among this class we may be hopeful of success to some considerable extent. Then there are many people who are not very particular what they eat, and by whom little selection in the matter of food is made. These people are in the habit of eating whatever is put before them, and as they pay little attention to dietetics, they simply eat whatever is considered good, wholesome food, so that this class is particularly amenable to the treatment about to be advocated. In fact, those who are not too dainty in their tastes, and who will not discard a piece of meat or other foodstuff because it is a trifle tough, generally have a fairly good set of teeth. Some men indeed, have a decided preference for eating things which they can feel between their teeth and which require chewing. Possibly it is to a certain extent due to their being deprived of a reasonable amount of fibrous food that they satisfy their instinctive desire to masticate by chewing tobacco. Perhaps it is the same instinct which makes many children relish so highly such a foodstuff (if it may be so termed) as licorice-root. Certainly in countries where it grows, children greatly relish eating sugar-cane. In this latter case there is also the additional satisfaction of gratifying the physiological requirement which the child has for sugar. In civilized countries, however, the craze for the elimination of the innutritious fiber, and the taking of the sugar in a form which can be wholly assimilated, prevents the importation of the fiber into the country, and the physiological necessity of the alimentary canal for nonassimilable matter is met by the sweeping down of some assimilable matter with a liquid, extract or powder of licorice.

But let us consider the subject from the beginning. It is necessary that an infant or child should be reared under hygienic conditions in general in order that the normal growth may take place. The natural food, of course, should if possible be given, i.e. mother's milk, and when the teeth are about to come through the gums, crusts of bread may be allowed with advantage.

As regards the diet of children after the teeth have come into position their natural instinctive preferences are on the whole a very good guide, but these are frequently quite different from the guides which are followed. As a general rule the majority of children, after they have their complete set of temporary teeth, have a dietary which is far too washy and easily administered with a spoon. Bread soaked in milk or spread with jam often figures prominantly as well as milk puddings, while the last meal of the day is little else than sweet biscuits and milk, often followed with sweets at bedtime!

A diet composed of such foodstuffs is not sufficiently varied, and as will be observed from what has been said, it is on the whole a very bad one for the teeth. With the exception of meat at the midday meal almost everything is apparently calculated to lodge and undergo rapid acid fermentation. The milk which is often a prominent part of young people's diet may, indeed, be harmless when consumed alone, as under such conditions it does not lodge to any appreciable extent, but when it is taken with toast, biscuits, milk puddings, etc., to a certain extent it is apt to lodge too long with such lodgeable foodstuffs and so promote the rapidity of the acid fermentation.

Now let us consider what might be an improvement from the point of view of the preservation of the teeth, while at the same time keeping the diet as good, if not better, from the point of view of the physiological requirements of the body. I think it would be found advantageous for children who are undergoing rapid development to have more albuminous matter, and inasmuch as eggs are not fibrous and do not clean the teeth to any extent during mastication, this concentrated form of albumen might be limited in amount, and a considerable amount of fibrous albuminous matter could be taken instead. Thus, at breakfast, fish or bacon might be taken in sufficient quantity to ensure mastication and the cleaning of the teeth.

With regard to the children's midday meal, the potatoes might be supplemented by vegetables, preferably in the raw form such as salad, and along with the meat, if more carbohydrates be deemed necessary, boiled rice, Yorkshire pudding, jelly, or other suitable adjunct to the particular kind of meat or fish might be taken without harm resulting. Then fruit might be given to finish the meal. I think if fresh vegetables and fruit were more in the routine of children's food, it would prevent the violent excesses sometimes indulged in when children get into an orchard, or even a turnip field, on some special occasion. There is no doubt that the continual non-satisfaction of the physiological want of vegetable acids and possibly uncooked fiber, is the chief reason for the excess sometimes indulged in, and at least it is improbable that if children had a proper amount of wholesome, ripe fruit and fresh vegetables, they would be likely to take an excessive quantity of unripe fruit when occasion offered.

With regard to bread soaked in milk, jams, and cake, these are particularly harmful. The bread should be of the whole-meal variety, and it might be eaten in the form of cress or tomato sandwiches. If jam or jelly is taken, it should be supped alone, or with cream or milk, and swallowed without mastication, and followed by something fibrous. A little fruit might preferably be substituted for jam at this meal and the liquid, e.g., water, should be taken after everything else has been eaten.

With regard to supper, if milk alone is not sufficient and it be deemed necessary to have something more substantial, then fish or some light meat should be eaten with the bread.

What I have just said is in no way meant to indicate the dietary necessary for children, but to show the practical application of my theory to the prevention of caries, and to point out that it is possible, even under existing circumstances, to give a child sufficient albuminous, amylaceous, fatty, saccharine, mineral, and innutritious matter, without everlasting milk puddings and bread and milk. That is to say, the physiological requirements of the body may be satisfied while giving the child a diet which necessitates acquiring the habit of mastication, which is very important from both a stomachic point of view, and for the preservation of the temporary teeth till the permanent ones are ready to take their place in a regular and natural manner. When we consider the ugliness and the remote consequences of an irregular set of teeth, I think it will be admitted that the extra amount of chewing which would be necessitated by the diet advocated would be sufficient compensation even though it only partially diminished the amount of caries and the irregularity of the teeth.

With regard to the diet of adults further suggestions here are hardly necessary. These may be found in previous chapters. Fortunately among adults there is greater freedom to eat what is gratifying, and to eschew what is not, and notwithstanding the temptation of refined foods, undoubtedly there exists in some people, especially men, a satisfaction in eating that which requires a decided amount of chewing.

There is little connected with dental surgery and pathology which may be considered settled with scientific accuracy, and my attitude to current ideas and methods had led me to doubt if even the time-honored method of cleaning the teeth with toothbrush and powder can be advocated without considering that it may possibly be harmful. We are aware that mouths which have never felt a toothbrush may occasionally be seen in which the teeth are all perfectly sound, and that as frequently people who are scrupulously particular in the use of the toothbrush have every tooth excepting the lower front teeth decayed and stopped in two or more places. Nor is this all. It frequently happens that the gums recede very rapidly in the mouths of those who use the toothbrush most and among this class too that painful and troublesome condition of erosion takes place at the neck of the teeth with or without recession of the gums or caries following.

Before stating the effect of the use of the toothbrush let us consider Nature's methods of preserving the enamel. First it may be preserved by being kept perfectly free from adherent matter as occurs on the crown surfaces of the teeth of those who eat coarse and non-lodgeable foodstuffs. Secondly, a protective layer of matter which does not become acid in reaction under normal circumstances may be deposited on the surface of the enamel and protect it from injury. Although this latter method is not recognized, I believe it is one which is utilized by Nature, and is perhaps the only possible and satisfactory method at certain situations on the teeth. Hitherto this coating has received little attention. It has been considered as merely so much deposit from the mucus of the saliva in a vitiated condition, or from other sources, and it is assumed that this should be eliminated by the aid of the toothbrush as quickly as possible. I intend, however, to point out that this coating on certain parts of the teeth may be considered physiological, and only become pathological under certain conditions.

Let us now consider the nature and source of this coating. There is reason to believe that its basis is buccal and salivary mucus. This is described as a viscid albuminous material containing albuminous mucus corpuscles frequently mixed with salivary epithelium and debris. In the situations where it adheres to the enamel of the teeth and is not removed during mastication or by the toothbrush, it may be felt by the tongue as a very thin slightly rough coating. It is frequently discolored either from chromogenic micro-organisms, pigments in the food, or from tobacco. From its albuminous nature and its being infected with micro-organisms it undergoes slow change. Its reaction on the surface of the teeth in the mouth is (as far as my testing with litmus shows) practically neutral. This reaction comes about presumably from the albuminous nature of the buccal mucus and corpuscles and salivary epithelium.

Although there are micro-organisms which infest this coating when no carbohydrates are mixed with or adhere to it in quantity, acid is not produced, at least in any quantity. Moreover, on account of the thinness of the coating, even if a small amount of acid at times is produced, it is neutralized by the saliva. I have found that in the morning, even after having eaten sweets on the previous evening, this coating is neutral in reaction.

The conclusion that this coating is normally of a neutral reaction is indicated by the fact that tartar is deposited in it in certain situations, e.g. round the necks of the teeth, with almost equal frequency as the decalcification of the enamel in similar situations. The cause of both decalcification and the deposit of tartar is similar—viz., the elimination of the coarse and fibrous matter from the foodstuffs and the lodging in quantity of food at the places referred to. In the one case, however, the reaction given rise to as the joint result of saliva, buccal secretions, and food, is acid (carbohydrates being in excess), in the other it is alkaline (albuminous matter being in excess).

When a toothbrush is frequently used the protective coating is brushed away from the necks of the teeth, and if lodgeable amylaceous or saccharine food is then eaten, the starchy matter lodges close to the necks of the teeth and the intensity of the acid formation is greater in close proximity to the enamel than it would have been had it been protected by a layer of albuminous mucus and corpuscles.

Thus, it appears that the toothbrush is not an unmixed blessing, but nevertheless until the ordinary food consumed is changed or has its fibrous element restored, perhaps the toothbrush may be usefully advocated at least for brushing coronal surfaces of the teeth.

With regard to antiseptic mouth washes, they too are not without their objectionable features. Beneficial as they may be in exceptional circumstances, under normal conditions their use is, I believe, to be deprecated.

"The mouth has never in the history of man or animal been an aseptic chamber, and paradoxical as it may seem, and contrary to all recent ideas relative to methods for the combating of caries, I will affirm that 'under proper dietetic conditions the bacteria of the mouth are valuable agents in the preservation of the teeth.' The mouth bacteria give rise to the continual disintegration and removal of the protective mucous coating supplied by the buccal secretions. It is difficult to imagine a better method for the prevention of caries at those places where the friction of fibrous food cannot dislodge all adherent matter, for while the mucous coating protects the necks of the teeth the bacteria provide a means for the removal of all accumulations of debris, whether it be decomposing food or incipient tartar deposit.

Now let us consider the object aimed at and the methods advocated in textbooks on dental surgery. The object is to free the buccal cavity from micro-organisms and the mucous, albuminous, and other matters which cling about the teeth. For this purpose the toothpick, floss silk, toothbrush, tooth powders, tooth soaps, and antiseptic mouth washes are advocated to be persisted in with irksome regularity and at inconvenient times. If the aim were achieved the very means for the natural method of preservation of the teeth would be destroyed.[3]

Let us consider the matter from an analysis of known facts. Food must, according to the physiologist, supply the following requirements; it must contain a certain amount of proteids, carbohydrates, hydrocarbons, salts, and water, and, what is most important from the point of view of the present paper, it absolutely must contain a certain and considerable amount of indigestible, innutritious, and nonabsorbable matter. This fact is very generally overlooked, and it is the origin of most of our digestive and dental troubles. Do not many of our children's troubles arise from constipation and the varied decomposing products generated in the intestine from the lodgment of food? Is not the very first step in the treatment to administer some drug which will clear out the foul mass of fecal matter? A very general state of affairs is first a gradual onset of constipation, then a purge, and the patient goes on well again with a tendency to constipation, which must inevitably increase if a reasonable amount of nonabsorbable matter is not given. Special care is taken not to give anything irritating, for if such food is given it will, of course, augment the evil effects of the fermenting mass in the intestines. But surely, this is a stupid way to go on. Would it not be much better to allow a moderate amount of inert, innutritious matter, such as cellulose, to remain in the foods? A sufficiency to stimulate mastication and the peristaltic actions of the entire alimentary tract to ensure a regular, and rhythmic performance of those natural functions? It is extremely difficult for the intestine to transmit tiny quantities—a "very considerable quantity" is necessary.

"This extraordinary care to employ nothing in our diet but matter which has nutritive value, that is, can be absorbed into the system, is founded upon want of knowledge of the first principles of digestion, and yet, strange to say, the mistaken indeed mischievous practice is supported, probably for want of thought, by many who ought to know better."[4]

Now let us turn our attention more especially to the carbohydrates. Let it be remembered that the starchy matters of the food are to a considerable extent digested by the action of the ptyalin of the saliva in the mouth. Let it be remembered, too, that when the starch passes into the stomach its digestion is after a very short time completely arrested. Now, if the starchy matter is much refined and taken in a form in which it does not require to be retained in the mouth and masticated then, of course, it is passed rapidly into the stomach and the salivary digestion is almost nil. The stomach is liable to be overloaded with undigested starch and the various disorders of amylaceous dyspepsia may result. If, however, the innutritious fiber, which is to a large extent cellulose, had not been removed or pulverized in the process of refinement, then the teeth would have had to perform their natural function; the food by its coarseness would have necessitated thorough trituration and insalivation; the starch would have been much more thoroughly converted; the stomach would not have been overloaded with an unnecessary amount of unconverted starch, and the innutritious cellulose would stimulate the rhythmical action of the stomach and intestine, which is frequently so sluggish.

With regard to sugar, the effect of refinement is particularly harmful. The refinement of the foodstuffs from which sugar is obtained is carried to such an extent that instead of the succulent tuber of the beet or the fibrous sugar cane we get the highly concentrated and crystalline product known as sugar. Now it is known that sugar can be easily swallowed in quantity, and the result on the gastric digestion is to cause irritation and an excessive secretion of mucus in the stomach. I think, too, that this excessive secretion of mucus takes place in the mouth from like irritation. The harmful effect on both teeth and stomach is generally acknowledged.

If, however, the sugar could only be obtained in the relatively unconcentrated form by chewing the beet or the sugar cane, the secretion of mucus might only be beneficial in coating the innutritious cellulose and putting it in a fit state for passage along the alimentary canal. Within limits, too, the mucus probably acts as a protective coating to the teeth. Moreover retention of sugar in the mouth in a dilute form, together with the fresh vegetable juices which accompany it in the sugar cane, stimuates the flow of saliva and facilitates its conversion into a less irritating and more assimilable form. The fact that the eating of sugar stimulates thirst suggests the natural need for its dilution, and the fact of the secretion of mucus suggests the adaptation of the organism to cope best with this article of diet when taken in the form in which Nature presents it to us.

With regard to proteids, they are usually eaten in a more or less natural state and the beneficial effect to the teeth is recognized, while, if the cooking is not bad, and the amount reasonably limited, the stomach is well able to derive benefit from them.

With regard to the salts, especially the earthy phosphates which are eliminated with the refinements of foods, for example, those contained in the husks of grain, the want of a sufficient supply of these in the diet may possibly cause some derangement in the natural functions of the digestive organs.

It should also be remembered that water taken after meals not only tends to cleanse the mouth, but when it passes into the stomach stimulates peristalsis and helps digestion.

There are also some general effects on the stomach produced by the refinement of foods to which attention should be drawn, for instance, the ease with which refined foods can be swallowed and the want of bulk composed of inert matter leads to a very general habit of overeating. The requirements of the body can be satisfied by a small amount of highly concentrated food, but if the inert and tasteless matter is absent the palate is keenly whetted, and until the stomach is moderately full more is easily eaten. If, however, a moderate amount of innutritious fiber has to be consumed, not only is the stomach gradually filled, but the amount of saliva swallowed is considerable and the digestive juices add their little to fill the stomach, and bring about a feeling of satisfaction.

In regard to children's feeding a correct knowledge of what is best is most essential; and here I should like to make a few observations in regard to a theory which seems to me to be worthy of consideration. It is known that a knowledge of the dentition of extinct animals gives a clue to the methods of feeding of these animals, and I believe a recognition of the dentition of children forms a guide to the correct feeding of a child. I do not refer only to the fact that up to the time of cutting of the incisor teeth the diet ought to be solely the milk which Nature supplies, nor to the fact that the existence of temporary molars indicates that food ought to be given which requires mastication. These facts are already recognized, at least theoretically, by many, but the perplexing period is the time between the cutting of the lower incisors and the appearance of the temporary molars. It is during this period that much difficulty is found in regulating the diet of infants, for the appearance of the incisors indicates that suckling ought to be supplemented with foods which stimulate growing as well as sucking. The child must be weaned. A sudden change to the foods which are procurable in a natural state would, as administered at the present day, give rise to gastric troubles. Natural foods are always accompanied with a considerable proportion of inert matter which would be apt, if not certain, to induce indigestion. Consider the instincts of the child and its indomitable habit of gnawing all edible substances presented to it together with its inveterate habit of sucking. Add to this that it first cuts two lower incisors, then the two upper central incisors, and shortly after the two upper lateral incisors. This being completed, there is a long interval of about five or six months before the cutting of the next group of teeth, which includes the lower lateral incisors and the four first temporary molars. Now during this time the child possesses two lower incisors. And they are sharp. Surely all this indicates that the best way to wean a child is to give it succulent foods which it can pierce with its incisors, especially the lower ones, and suck the juices from such foods. Why should starch be so difficult for the infant to digest? Surely it indicates that during the process of evolution the child sucked soluble matter. To supply the carbohydrate food and the sugars, the soluble starches and the vegetable juices would be consumed. Doubtless the craving for sugar and vegetable acid indicates a beneficial provision of Nature to put the child in fit correspondence with its natural environment. This undoubtedly would supplement the delicate morsels from the animal and vegetable kingdoms which the primitive mother could procure for her child. No doubt too the fresh vegetable juices exert beneficial effects, at least it is generally recognized that a good supply of these juices are necessary to prevent the occurrence of scurvy, rickets, and other diseases which are usually inflicted on infants through the agency of misdirected civilization. Therefore children should not get much inert and innutritious matter from about the seventh to the fourteenth month.

With the advent of the temporary molars more solid food should be given, and at this period starch can be much more easily borne. By this time the salivary glands have largely developed, and the stimulus given by continual gnawing and sucking largely promotes the growth and functional development of these glands. Next consider the shape of the molars. Is there not a large grinding surface on each? If man were a carnivore this would be hardly necessary, but being partly a vegetable feeder it is necessary for the vegetable food to be masticated, for the cellulose enveloping the starch to be crushed, and for the starch to be at least partly digested while in the mouth. By the time all the temporary molars are in position the child is able, within limits, to eat anything, and only a vicious civilization is able to undermine the natural and powerful digestion, which by this time should have been gained.

Although the working out of the theory of prevention of irregularities of the teeth naturally devolves upon us as dentists, yet in the early stages at least the carrying of the theory into practice must devolve upon the medical practitioner or those who supervise the bringing up of infants and children. The prevention of irregularities should commence indeed before the eruption of the teeth.

It is unnecessary to advocate that an infant should be breast fed; this is quite well recognized. But as it frequently happens that artificial feeding must be resorted to, and it has been noticed, or at least it should have been noticed, that irregularities of the teeth are a frequent sequel to artificial infant feeding, it will be as well to state that, according to my views at least, artificial feeding is not the cause or necessary consequence of the irregularities.

Gnawing and sucking is an instinct with all children, and the satisfaction of this instinct is no doubt beneficial, so that after some teeth have appeared the food should be of such a consistency that it will demand the use of the teeth. Sugar cane is a useful adjunct in the dietary of a child, but it is unnecessary to return altogether to primitive foods. Even highly artificial products, such as stale bread, crusts or toast, will suffice as part of the diet, but vegetable food rich in carbohydrates, should be so dry or of such a consistency that they will absolutely necessitate mastication and insalivation. The recommendation in otherwise excellent treatises of a diet consisting almost wholly of "bread well soaked" in milk and the like[5] shows a compete disregard of the physiology of mastication. It should surely be remembered that physiology of digestion is not a piecemeal business. All parts of the process are intimately co-ordinated.

To recapitulate: The food of children should be of a chemical composition, as is found in milk, and such as is advocated currently in textbooks dealing with this subject, but the physical characters of the solid food should rather diverge from that of milk in correspondence with the position and number of teeth erupted; that is, it should be the opposite of that currently advocated. When, for example, we read "a rusk or slice of stale bread well soaked" we should read a rusk or slice of bread well dried or toasted.

The next factor to be considered is the prevention of mouth breathing. We have already alluded to the fact that efficient mastication tends to broaden the nasal passages, and that narrow nasal passages predispose to the blockage of the nose and the occurrence of adenoids, but the exciting cause, colds in the head, must also be counteracted as quickly as possible, for, as has already been mentioned, the fact that the blockage of the nose arrests its development, is proved. We may be content with the simple idea that the abeyance of its function of transmitting air tends to arrest its development, for with each inspiration there is a stimulation of the flow of blood when there is no obstruction. On the other hand, the abeyance of the rhythmical stimulation of the flow of blood is amply sufficient to account for the arrested development when the passage is permanently blocked.

Towards the close of the last century there sprang up a school of biologists who denied that acquired characters were transmitted. The question being one of great importance and interest, I made as full an investigation of the arguments which had been advanced as seemed necessary for me to come to a definite conclusion. I was fascinated with the subject, and became a disciple of the new school. The question arose, however, that if acquired characters were not transmissible, then what became of the current assumption that the jaws were growing smaller on account of successive generations of disuse?

My studies had so thoroughly convinced me that acquired characters were not transmitted, I felt that some other explanation could be made which would account for the diminution in size of the jaws and the irregularities of the teeth. The explanation, however, did not come at first. At last the idea struck me that there might be an intimate relation between the size and growth of the tongue and the size and development of the jaws, and that this would best explain the facts without any assumption of the inheritance of acquired characters. The facts with which I was acquainted were so easily harmonized by the hypothesis, that in a few hours I had roughly sketched out in my mind the theory that I am about to explain.

This is not my only justification for introducing another theory of the causation of irregularities. It is well-known that "some theories are the very foundations of science; while facts are the building stones, theory furnishes the design; and it is the interpretation of facts in the light of theory, and the considered application of theory to practice that constitute true science."[6]

"Further, a new theory tends to stimulate thought, and this is at present of particular importance, for current conceptions of the irregularities of the teeth are so confused that thought seems to be completely paralysed."[7]

Notwithstanding this, it is encouraging that the theory has already been adopted in general by a few scientists as well as a few distinguished practitioners both dental and medical. One eminent surgeon has most ably corroborated my views in a recent paper, and has, I believe, considerably helped "to secure for them a more generous recognition than has hitherto been accorded."[8]

The first indication of the acceptance of my views may be found in a communication given by the late Sir J. Arbuthnot Lane, M.S., F.R.C.S., entitled, "Some Points in the Mechanics of the Jaws," which helped materially to corroborate my views published between 1900 and 1903. It should really be read in association with his previous contentions with regard to the influence of atmospheric pressure not only on the bones which surround the nasal cavities but also indirectly on the lower jaw.[9] However, to get on with Sir Arbuthnot's reflections on my views I need only quote the greater part of one paragraph which Mr. T. E. Constant made in the discussion when he said:

> "Dr. Sim Wallace has for some years insisted upon the importance of the tongue as a factor in the development of the mandible, and his teachings have so far been received with the studied indifference which is characteristic of the attitude of the more responsible members of the dental profession in England towards original observation and research. It is to be hoped that the corroboration of his views by Mr. Lane will secure for them a more generous recognition than has hitherto been accorded."[10]

The next speaker to take part in the discussion was Prof. J. E. Grevers of Amsterdam who was rather in sympathy with my views and went to the trouble of translating into Dutch a few articles of mine with regard to the Solution of the Problem of Susceptibility and Immunity to Dental Caries, from which quotations, to my way of thinking, are of importance not only with regard to dental caries but also to irregularity and crowding of the teeth, recession of the gums, pyorrhoea and oral hygiene generally. Therein I noted that a subject of great concern of which we must beware, was the fact that the modern refinement and preparation of food which makes particles lodging between the teeth peculiarly nonirritating. If the food is highly refined "short" and soft, it may be plastered into the crevices of and between the teeth after meals, without stimulating saliva, or exciting the tongue to dislodge it, but if for example nuts are consumed, there is something in their physical nature which makes one very conscious of their presence and stimulates not only the flow of saliva, but also the motions of the tongue and cheeks until they ultimately are dislodged.

So also the modern preparation of food tends to deprive it of the natural fresh vegetable acids which would otherwise almost invariably accompany vegetable foods of a relatively innutritious nature. Thus it correspondingly happens that the saliva is not so fully stimulated as it should be. Now when acid is taken into the mouth not only is the saliva stimulated directly, but the acid which reaches the stomach also stimulates the flow of saliva. The importance of what we may call the after-flow of saliva can hardly be doubted. For the frequent swallowing which it causes after meals is a most potent factor in the self-cleansing of the mouth.[12]

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*My brochure entitled, *Solution of the Problem of Susceptibility and Immunity,* is at present out of print but may be consulted in *The Dental Record* for November and December 1903 and January 1904; or in *The Dominion Dental Journal* for March 1904; or translated in the *Tidjschrift foor Zandheilkunde X1E Jaargang, A fl. 1.*

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# Chapter IX

## MODERN DIETETICS IN THE CAUSATION OF DISEASE

Before proceeding to make a short resumè of the *Rôle of Modern Dietitics in the Causation of Disease* let me refer to the use of such words as "coarse" and "fibrous." I have, however, long recognized that there are limits to the eating of "coarse and fibrous food,"[1] for two reasons. Firstly, there are some foods which are very efficient in stimulating mastication, but which are not conspicuously fibrous. For example, an apple, although distinctly fibrous when compared with cheese or the white of an egg, is not in ordinary parlance called fibrous. Secondly, there is a psychological reason, for when the word fibrous is used with regard to food it seems to excite in many minds the idea of something disagreeably tough. Thus although I may yet use the word for brevity, it should be understood that my meaning is simply that consistency of food *which stimulates the pleasurable activity of efficient mastication.*"[2] A year before this, a note was made that "cellulose is strongly advocated both from the point of view of the teeth and alimentary canal, but derivatives of cellulose such as lignin and suberin should only be consumed sparingly. Thus, the skin of fruit should as a rule be removed and wholemeal bread indulged in with discretion.

"It must not be supposed however, that the rôle of cellulose cannot be largely, if not entirely, filled by any other article of diet. Thus with the Eskimos, oil or fat takes the place of cellulose, and even in European countries children are frequently restored to health, at least for a time, by the aid of continued doses of castor and cod-liver oil."[3]

Other points were in a way unduly stressed; for example when giving a selection of foods suitable for *stimulating the growth of the jaws and preventing crowding of the teeth,*[4] I gave a list of the foods from which satisfactory meals may be chosen for children with a complete set of deciduous teeth.

"Breakfast: Fish (various kinds, variously prepared) toast crescents, rolls, oat cakes, brown bread, fruit, e.g., apples, bacon. *No porridge.*

Dinner: All kinds of meat (not minced), poultry, fresh vegetables, salad, bread rolls. Rice pudding, made as in China, with every grain solid

> and separate. Fresh fruit. *No sloppy milk or custard puddings.* Nuts, *no nutritious soups.*
>
> Supper: Toast, rusks, bread rolls, oat cakes. Meat, fish or poultry. Fruit. *No bananas.* As regards liquids, water is the ideal, milk should be avoided."

Other points were in a way unduly stressed. In order to emphasize the benefits of mastication, I tried to indicate that children over the age of two and a half years could easily be allowed such foods as stimulate the growth of the jaws so as to prevent crowding or irregularity of the teeth. No doubt it was not alluring to italicize the words "no bananas," though they do not stimulate *vigorous* mastication. But they are cleansing with regard to the teeth especially after sweet cakes, biscuits, bread and jam, etc., have been eaten.

To come to closer grips with the subject let me give a few excerpts from my book on *Modern Dietetics in the Causation of Disease.*[5] Philosophically speaking, the cause

> "is the sum total of the conditions, positive and negative taken together, the whole of the contingencies of every description, which, being realized, the consequent invariably follows."[6]

The cause of a disease may or may not be the immediate antecedent, and whether the immediate antecedent shall be designated the cause, depends on whether it is the antecedent which may be remediable or advisedly altered. When remediable it is unnecessary to pursue its antecedents further; however, where it is not, we must find a prior antecedent which is remediable, even though this is complex and requires its connection with the immediate cause explained. As an example of this we may refer to the cause of dental caries. When the pathology of this disease was elucidated, it was found that the invariable and necessary antecedent was acid fermentation, or acids and micro-organisms. It was quite natural to consider that this was the cause, and having done so, to advocate the use of antiseptics and alkaline mouth washes, for by this means it was expected to prevent the disease. However, as it has been found that the effect of these antiseptics and antacids has been quite unsatisfactory as a means of preventing the disease, the cause has been sought in a prior antecedent, that is to say, in some dietetic error, which if rectified, the disease does not take place. Now we recognize the cause of dental caries to be that the natural foodstuffs are to a large extent deprived of their accompanying fibrous parts, and prepared and consumed in a manner which renders them—especially the carbohydrates—liable to lodge and undergo acid fermentation in the mouth.

A somewhat perplexing circumstance is brought to light in investigating the causation of disease, for it so happens that the antecedent which we wish to avert may be an absence of some particular condition. Thus, for example, we are justified in saying that lack of the proper nutritive constituents in the food causes certain deviations from a normal state of health, and certainly a case of starvation will justify us in saying that lack of food is the cause of the condition. This is confusing, since the cause is generally supposed to be a positive agent. I emphasize this, as it so very frequently happens that diseases do arise from *lack* of the normal conditions which should obtain . . .[7]

"A survey of the above leads us to conclude that in general, disease is caused by imposing environmental conditions upon the individual differing from those which are obtained during the evolution of the species; while disease is prevented by maintaining the essential similarity of the environment to that which is obtained during the evolution of the species. This simple, obvious, important, and useful generalization is very frequently overlooked, and by modern writers on dietetics is completely ignored."[8]

The second chapter was devoted to The Increase and Decrease of Disease and commenced as follows:

"In a general survey of the progress of medicine one of the most pleasant features is the decreased prevalence of most diseases. This and the kindred consideration of the decreasing mortality is often referred to with a certain amount of pride by the medical profession. On the other hand the increased prevalence of certain diseases is generally overlooked, or mentioned together with some more or less plausible argument or statement, which mitigates the painful impression which otherwise might be conveyed by a consideration of the lamentable fact. . . . We may mention a few diseases which have increased in frequency. The diseases and irregularities of the teeth, adenoids, appendicitis, neurasthenia associated with gastric insufficiency, infantile diarrhoea, 'indigestion', anaemia, rickets, internal cancer in men, and insanity.

"It may be noted in passing that all these diseases are more or less directly associated with digestion or the digestive tract, and how they result from the modern practices and theories of dietetics will be suggested in the following chapters."[8]

Now consider some typical examples of the most important, and at one time common, diseases which have decreased in frequency. Typhus fever, relapsing fever, rabies and smallpox have almost vanished from the country, while the ravages of tuberculous diseases have been largely curtailed. It may be noted that these are diseases depending largely for their propagation on foul air, infection, and unsanitary surroundings. That a certain group of diseases connected with the digestive tract should have increased, while those depending on sanitary surroundings should have decreased, is noteworthy, for unsanitary surroundings certainly cannot be beneficial to the digestive tract, nor can an impaired alimentary tract be anything but conducive to the inception of diseases primarily dependent upon unsanitary surroundings.

That the food we consume and more especially the food which children are compelled to consume, is in some respects radically different from that which was consumed in bygone ages may readily be observed when we recognize that cow's milk and the prepared cereal foods were quite unknown to precibicultural man and all his progenitors. The processes of refinement, and the elaborate methods of preparation of food should at once suggest that the alimentary canal may not be wholly or perfectly adapted for the foods which are now presented to it. Of course it will be claimed that the methods of preparation are brought into existence in order to suit the requirements of the alimentary canal, and in some ways it may be admitted that the end desired is partially attained. The question however is, has the process of refinement not frequently brought unexpected derangements? An inquiry into the nature of the foods which have been subjected to refinement shows us that the refined products are much more nutritious, and that the innutritious matter which naturally accompanies natural unprepared foods is partially or even totally eliminated, as for example in sugar. As a very general rule the matter which is excluded is cellulose, an inert, indigestible or rather a nonassimilable material of a more or less fibrous nature. Thus a result of the refinement of food is the elimination of this part which on account of its physical nature demands a large amount of mastication.[8]

Several other factors which have led to the craze for highly nutritious foods will be noticed in succeeding chapters, and the above remarks must only be considered as introductory.[8]

Mastication and Some Effects of Refinement of Foods were then dealt with and in the fifth chapter I referred to the evil effects of Nasal Obstruction and Mouth Breathing in as much as it tends to prevent the use of the muscles of mastication and the development of the tongue. A diagram is given to illustrate (1) palate and normal position of the tongue and (2) when the tongue is small or emaciated during the development of the palate.

Following this is a chapter on Physical Deterioration in Relation to the Teeth in which among other things, three points are referred to.

"First let us ask whether the degenerate state of the teeth is a result of general physical degeneration. Have we any substantial evidence that the ill-developed classes have teeth more susceptible to decay than those whose physical development is distinctly good? I venture to believe that there is not."[8]

It must, however, be recognized that general and prolonged ill-health tends to diminish the amount and vigor of mastication, which in itself predisposes to caries. Nevertheless, I do not contend that these predisposing causes are of any great moment when brought about by a state of imperfect development alone.

It is not only by inducing caries, however, that the teeth may be injured. Their use and their beauty may be greatly impaired by irregularity. Physical degeneration and irregularities of the teeth are necessarily intimately correlated, because the conditions which give rise to imperfect development are almost invariably associated with prolonged malnutrition and emaciation, and general emaciation is practically always associated with emaciation of the tongue. I cannot here enter into how the development of the dental arches and jaws is dependent on the development of the tongue, but I have no hesitation in saying that it is a fact. Secondly, we may consider the question whether physical degeneration may or may not be due, as a general rule, to bad teeth. To this question there seems to be but one answer. We cannot expect physical development to go on satisfactorily so long as the teeth are decaying or are otherwise diseased. How this must necessarily be so is well known to all of us: Dental caries is simply an outcome of oral indigestion. The carbohydrates are not digested as they ought to be; they are neither subjected to the churn-motions of mastication nor the insalivation they require, for they are, as a rule, nowadays presented to children in a state which stimulates neither mastication nor flow of saliva. All parts of the function of digestion are necessarily intimately correlated, so that it does not surprise us that this disturbance of the first stage of digestion is very apt to upset the normal workings of the stomach. Of course, if digestion does not go on satisfactorily, neither will physical development.

In addition to this we must consider the carious cavities, their contents and consequences. We can hardly imagine that the products of the numerous bacteria associated with caries can by any possibility be otherwise than detrimental.

Lastly, let us direct attention to the question whether there is anything in our surroundings or general mode of living which is prejudicial both to the teeth and to general physical well-being. I venture emphatically to submit that there is. Medical science has made such progress, we hardly dream that something may have been overlooked. Yet an investigation into the subject will prove that it is so.

> "What is true of science generally is likewise true of every scientific problem. Everything does not mean advance; we often meet with a standstill, sometimes take a retrograde movement. A striking example of this is shown in the investigation of the salivary glands. After the appearance of the classical work of Mitscherlich, and a number of talented investigators, such as Claude Bernard, Schiff, and others,"

there came a retrograde movement, and now what we read in our textbooks would lead

> "one to suppose that the work of the salivary glands is of no import, and that they respond in haphazard fashion to every form of stimulus."[9]

Working from quite another standpoint I came to recognize the importance of a similar conclusion. I had been struck by the marked superiority of the teeth of those who ate the least soft and refined food, and also saw what appeared to me good evidence that those who had been brought up on, and continued to eat, natural, unrefined food, had a much better digestion than those who ate the most refined and apparently physiologically digestible food. In other words, I came to the conclusion that food which demanded efficient mastication was not only best for the teeth, but for the stomach and intestines also.

It is interesting to see how certain experimental procedures have given rise to most disastrous conclusions. Some experiments were made outside the body showing, it was supposed, how gastric digestion went on. Here was apparently unquestionable evidence set before one's eyes showing digestion going on in a glass bottle. It was seen that finely-divided particles were rapidly digested, whereas the process was slower if the pieces were large. Now, nothing could have been more natural than to advocate that the food should be refined, pulverized, or ground, so that the digestive juices would be more able to deal with it. It was not anticipated that this refinement would tend to make children swallow their food with little or no mastication. Nor was it expected that by habituating the child to swallow without mastication it would contract the habit of swallowing even lumps when these at times got into its food. Nor was it imagined that the teeth thus deprived of their natural function would decay and give rise to all the troubles to which we shall refer. It was not expected that this interference with the first stage of digestion would disturb nutrition and consequent healthy development.

It was not anticipated that this disturbance of the health and nutrition of growing children would lead to a craze for more nutritious food. It was not seen that this craze for nutritious food would lead to a still further elimination of the innutritious fiber which demands mastication and is commonly associated with natural and unprepared foods. Nor that this would appear still further to necessitate refinement of the food, and make it seem a necessary accompaniment of civilization.

Another convincing corroboration of these views is to be found in a consideration of the increased prevalence of certain diseases. In a general way, it may be said that we are in less danger of disease than were our ancestors. The advances of sanitary science, the steady progress of medicine, and the control and conquest of one disease after another, together with the general increase in comfort in which we find ourselves, all tend to physical well-being and freedom from disease. But notwithstanding this general amelioration, there has been an appalling increase of those very diseases which have their origin in the soft, refined, and highly nutritious foods, which stimulate the muscular activity neither of the jaws nor stomach nor intestine. Dental caries was once an almost unknown disease; now in England, at least, it is the most prevalent of all diseases. Indigestion and constipation have become so common that they are looked upon as almost necessary concomitants of civilization. Increased mortality is caused by diarrhoea resulting from undue lodgment and consequent fermentation of food in the intestine. Appendicitis, from the lodgment of fecal or other matter which the weak or sluggish intestine is unable to pass on, is an alarmingly fashionable disease. Neurasthenia, arising from gastric and intestinal insufficiency, is now quite common, although a generation ago even the name of the disease did not exist. Adenoids have become so common that a new class of surgeons is kept busy removing them. Lastly, anemia and rickets, presumably from malassimilation and oral sepsis have increased. Yet, in spite of these terrible facts, the nutritious pap system of feeding children is gaily advocated by intelligent and responsible physicians![10]

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# Chapter X

## IDEAS CURRENT FROM 1900-1910

At the beginning of the present century, there arose an idea that physical degeneration was the predisposing cause of many diseases. Particularly was it believed that the lamentable state of the teeth gave obvious evidence of this alarming supposition. It seemed to flatter the vanity of civilized mankind to harbor the idea, that as the result of our great learning and mental activity, the blood was diverted from the jaws and teeth in order to supply the needs of our wonderful and overworked brains. Well, I did not share in this congenital belief, as it was my good fortune to have been brought up on the teachings of August Weisman and Francis Galton, to "whose magistral studies on heredity have made us all their debtors." This was acknowledged by Sir J. Arthur Thomson in dedicating his own work on Heredity to them. Naturally, after becoming legally qualified to practice medicine and surgery together with a diploma in dental surgery, I ventured to give a rather long address dealing with Physical Degeneration and Dental Caries. I need not now repeat what I said, especially as it was republished in my book on the *Role of Modern Dietetics in the Causation of Disease* in 1905. Nevertheless, it may be well to quote extracts from a leading article in the *Medical Press* which commented on my address as follows:

"A paper was read by Dr. Sim Wallace at the recent annual meeting of the British Dental Association at Aberdeen, on the connection between physical degeneration and dental caries, in which an original line of reasoning was followed with the object of showing that it is to the food of the people that their dental troubles must be attributed. Without committing ourselves to Dr. Sim Wallace's conclusions, we may say that his paper was suggestive, and deserves to be well pondered. He began by pointing out that there is no evidence that the ill-developed classes of society have teeth more susceptible to decay than those of good physical development, but . . . it is in his opinion that food demanding thorough mastication in the mouth is not only best for the teeth, but for the stomach and intestines also, and that the early decay of the teeth and the sluggish action of the alimentary canal, which is evidenced by indigestion and constipation, are the direct outcome of the habit of eating refined, soft food. Such foods allow the function of mastication to fall into desuetude, and teeth decay and the digestive functions become perverted. All these circumstances lead to a demand for still softer and more nutritious foods, and the evils are perpetuated in geometrical progression. Dr. Sim Wallace is prepared to attribute to this unnatural tendency not only dental caries, but also such diseases as appendicitis, rickets, neurasthenia, adenoids and anaemia. We are inclined to agree with him that the preparation and quality of food used at the present day are some of those circumstances of civilization that operate differently to what have been expected. *It is a well-known fact that the physiologically perfect products of the laboratory combined in theoretically perfect quantities frequently fail to nourish those to whom they are administered, whilst natural foods* that contain much that appears unnecessary *and harmful, agree well.** No one can regard with pleasure the consumption, now so fashionable, of artificial, concentrated food products, and it is quite possible that the indigestible parts of natural food may have a useful function to perform in the economy. One of these functions may certainly be that of keeping the teeth in healthy order, and, if this be so, while the present dietetic arrangements in the community persist, it is not likely that any amelioration in the teeth of the race will take place. . . . At any rate, the whole subject is one of so much moment that no efforts to ascertain the facts should be neglected. Dental caries has been lightly regard far too long; it is now assuming dimensions that are more or less alarming."

Now let me refer to what further I had to say on the subject in 1906. Dr. Harry Campbell had already written an important series of articles in the *Lancet*.[1] He concluded by referring to and supporting my views with regard to the value, or otherwise, of the toothbrush, tooth powder, and antiseptic mouth washes, and was even more emphatic in condemning their use than I had been. It is also satisfactory to note that about this time recognition was taken of the more important consideration of the influence of the physical nature of the food in the causation and prevention of dental caries. Thus, the Royal Dental Hospital has recently issued a pamphlet on "Instructions on the Care of the Teeth," which says:

"The kind of food eaten has a great influence on the teeth. Soft foods are more liable to cling about the teeth, whereas harder food, which is often more easily digested, requires more 'biting,' and in this way the teeth are kept cleaner and the growth of the jaws assisted." Similarly, another important pamphlet issued by the School Dentists' Society, "On the Care of Children's Teeth," says "that after the eruption of the molar teeth the food should be *of a firm and fibrous consistency.*"

I shall now indicate briefly the general acceptance which these views have gained.

Mr. J. F. (now Sir Frank) Colyer, formerly Dean of the Royal Dental Hospital, and author of the most widely read textbook on dental surgery and pathology, expresses his conviction that dental caries is a preventable disease. He advocates lines of prevention very similar to those just indicated. I need hardly say that he did not come to do so without a thorough investigation of the various grounds on which the method was based. He, like others, recognized that "the acceptance or non-acceptance of the doctrine of the inheritance of acquired characteristics profoundly alters our conception of disease," and, referring to my criticisms of the views which used to be dominant in our specialty, he said: "These criticisms made us think, with the result that our views on the inheritance of bad teeth, crowded arches, and so forth, have greatly changed. We have examined the problem from a broad point of view, and we, too, find that much we considered as due to heredity is in reality 'similarity of environment'—a view which does give us some hope that the problems of disease confronting us are not insurmountable."[2]

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* (Italics mine. J. S. W.)

The following quotation from Sir Frank Colyer's book on Dental Surgery and Pathology[3] will indicate what dental students are now taught on this subject:

"In discussing the cause of caries, attention was drawn to certain matters which appear to have a special bearing on the increase of caries—namely, the feeding in infancy, and the character of the foodstuffs, etc. A consideration of these seems to indicate that preventive treatment should be based somewhat on the following lines:

"(a) The insistence when possible of breast-feeding.

"(b) The use in early years of life of foodstuffs which require efficient mastication.

"(c) The use of carbohydrates which are not easily fermentable.

"The use of such *foodstuffs* as call for some effort in mastication is important, and 'pap' food should, as far as possible, be carefully avoided. A very little experience of children will demonstrate the importance of this point. Bread soaked in milk is bolted, while bread given in the shape of a crust or a piece of toast is chewed, simply because the chewing is physiologically necessary. For similar reasons, meat, when given, should be cut in strips and not minced. Mastication promotes a healthy flow of saliva, and the saliva assists in cleansing the teeth.

"There is little doubt that of the carbohydrate foods, the sugars are the most harmful, especially when taken between meals. *'Sweets,' as popularly understood, should be forbidden.* As carbohydrates are now known to be the source from which the lactic acid is derived, it is advisable so to arrange a meal that the last foodstuff taken is neither a sugar nor a starch. A meal should, if possible, finish with fruit or cheese. Fruit is especially beneficial, as it is slightly acid and stimulates the saliva. Meals should be given at regular intervals. If the salivary secretion is constantly being stimulated by incessant 'nibbling' at food it is probably robbed of its physiological properties, and the supply required for the regular meals is depleted and probably altered in character."

I need not refer to the artificial methods which Sir Frank Colyer regards as of secondary importance.

Another eminent dental surgeon, Mr. J. H. Gibbs, F.R.C.S., L.D.S., at one time Honorable Dental Surgeon to King George V in Scotland, and Examiner Royal College of Surgeons of Edinburgh, said:

> "The causation of dental caries was known, and it was also known how by very simple dietetic measures the amount of caries could be reduced to very small and almost negligible proportions. The only feasible way of attacking the problem of dental caries in the children of the masses was by prevention, and the cost would be trifling and the educational value enormous. One of the great obstacles to progress along this line was the ignorance, apathy, and even opposition of so many general medical practitioners. One had only to glance at any orthodox book on dietetics to see that the whole teaching was calculated to the production not only of dental caries, but of gastro-intestinal and other disturbances. Naturally, one could not expect the average general practitioner to be more enlightened than the dietetic specialist, but one must recognize the fact that until medical men discard the suppositions upon which the present teaching of dietetics are based, dental caries and many other children's ailments would flourish.[4]

A few medical officers of health have for some time recognized the grave importance of the subject; thus, Dr. James Wheatley has been most enthusiastic in his advocacy of the new views on oral hygiene, not only because of the teeth, but because of the beneficial results which the proposed reform would bring about with regard to other diseases. In fact, because of its direct and indirect results, he regards it as the most important problem of preventive medicine.

I suppose readers of *Dental Items of Interest* interested in the subject are acquainted with the excellent summary which Sir George Newman has written in his annual report for 1919 as Chief Medical Officer of the Board of Education, together with the equally excellent statement on children's diet, in relation to dental disease prepared for him by Mr. (now Sir) Norman Bennett, who in 1930 became president of the British Dental Association, so I need only call attention to one sentence in Sir George Newman's report. He says:

> "There are few questions of greater moment calling for the attention of the Health and Education authorities than this one of diet, both in relation to teeth and to the general nutrition of the child. The problem concerns both the most suitable forms of food and the best methods of feeding at the different periods of life. A suitable and sufficient diet is one of the most pressing requirements in relation to the national health."

Even those who believe that, owing to the abeyance of natural selection, the teeth are degenerating in some way which makes them susceptible to decay, put emphasis upon the importance of diet as a means of preventing dental caries. Thus Mr. Stanley Mummery, who claims "that the chief cause of the increasing prevalence of dental caries among civilized races lies in the *teeth themselves,"* says there are two distinct types of cleanliness —natural cleanliness and artificial cleanliness. Of these, natural cleanliness is by far the most desirable. . . . It consists chiefly in the regulation of the diet, preference being given to such foods as do not tend to stick around the teeth, and the elimination from our diet, as far as possible, of soft, sticky, and easily fermentable foods which are not easily washed away by the saliva during mastication.[5] Those dentists and doctors who put the theory into practice in their own families half a dozen or more years ago are still able to record most excellent results, and thus have indicated in a practical manner their belief in the new method.

I have quoted those authorities to indicate that there is now a great unanimity as to the preventability of the disease and as to how it may be prevented, but it need not be assumed that all details in regard to the etiology and prevention of the disease are settled beyond controversy. There is still room for further investigation, and medical officers of health have an excellent opportunity for research of a statistical nature which would be of great value.[6]

Now let me refer to somewhat opposing views. If in the prevention of caries we have relegated the use of the toothbrush, tooth powders, antiseptic and alkaline mouth washes to a quite subsidiary place, can we report progress in ideas with regard to any other method of combating the ravages of the disease? I venture to think we can. At the same time, we must recognize that those who admit at least a considerable amount of truth in the evidence upon which the proposed method is based, doubt its practicability. Thus some of our most distinguished confreres have pronounced it as "impossible." Mr. (now Sir Kenneth) Goadby, for example, writes thus:

> "We have seen from a rapid survey of the pathology of the mouth that the foodstuff question is an all-important one. It is moreover, well known that our methods of food preparation have undergone very considerable changes during the last half-century, and a very large number of fine carbohydrate preparations are on the market, and have a wide sale. While the preparations are of such a nature, the mechanical effects of mastication in cleaning the teeth and gums is nil; the carbohydrate itself is not bad, but the fact that it remains around the teeth is the evil. It has been suggested, and I think with not a little truth, that could we return to a diet containing a larger quantity of fibrous matter, we should largely reduce the incidence of dental disease. It is, however, an impossible task to change the food of a nation."[7]

I admit that at one time I, too, doubted whether it would be possible to effect the necessary reform. At that time I had the idea that there was a science of dietetics, and that the methods advocated for the feeding of children were physiologically correct; but this was an error. Recent investigation has conclusively proved that the restricted diet which children are *compelled* to subsist upon takes little heed of the physiological, anatomical, and instinctive requirements of the child, and results not only in ruin of the teeth, but also in physical deterioration in general. I cannot enter into this subject here; I have recently done so elsewhere.[8] Suffice it to say that, if children are fed according to physiological principles, while hygienic requirements are not neglected, the teeth will not decay, nor will the other diseases which result from the infringing of physiological laws be at all likely to be prevalent.

It is my conviction that if the dental armamentarium is not more or less destroyed, and if morbid tastes are not initiated before a youth gets "on his own," we need not fear that he will by preference take to pap-feeding and vagaries of diet which lead to the destruction of the teeth. We shall see later that the physiologically correct food is greatly to be preferred by the epicure, provided he has got his teeth, and is accustomed to use them.

I do not intend to go at all fully into the question of diet here. It is rather my intention to show how anything may be given to children without harm resulting. Certain apparently trivial considerations, however, in the routine dietary may be referred to. The first is that much the greater part of the diet should be of such a firm consistency that it will *necessitate* efficient mastication. It is sheer folly to attempt to teach a child the habit of masticating thoroughly if at the same time a soft or milk-soaked diet forms much the greater part of the meals. Yet this is what is actually advocated in books on children's diet provided by our distinguished colleagues in the medical profession for the guidance of mothers. A child thrives just as well if it eats its rusk, or what not, and then drinks its milk and water as if it swallows rusks soaked in milk; indeed, it thrives much better, for however much it may have been neglected in the past, we now recognize the advantages of mastication, insalivation, and preparation of the food *in the mouth*, while we also recognize the harm of cheating the teeth of their share in digesting it. Then, again, it is ridiculous to advocate a liberal supply of fat in a child's dietary if by encouraging swallowing without mastication we induce a morbid craving for sugar and actual revulsion to fat.

It should be realized that the palate is an important monitor in the natural selection of foods. If, for example, a child masticates a slice of toast thoroughly, a considerable part of the starch becomes converted into sugar in the mouth, and the palate appreciates the amount of carbohydrate consumed, so that after a time it gets satiated with this particular variety of food, and is willing to take fat. If, however, the carbohydrate is soaked in milk, it is rapidly slipped past the taste organs, and consequently the palate craves for more of the carbohydrate, as it is not cognizant of the amount already consumed. Whether this idea be considered correct or not, as a matter of fact, the only child that I know of, who of his own free will eats lumps of fat of all kinds, is a child who was deliberately brought up, on food which necessitated thorough mastication. His parents, I may say, at the same age both revolted at the idea of eating the least shred of fat; indeed, his father only learned to eat butter at the age of eighteen.

The next point that I would drew attention to is the arrangement of the menu. Cookery is an art by which man has been able to bring to his use multitudes of foodstuffs, which without its aid he was debarred from enjoying, but although it has been one of the most important triumphs that man has made, it does not necessarily follow that it is an unmitigated blessing. Cooking not only softens food, but it makes the carbohydrates more fermentable and more likely to lodge in the mouth. Now, it is not my intention to advocate a return to primitive foods and an abandonment of cooking. It is my intention only to show how the disadvantages which are associated with our modern methods of preparing and cooking foods may be overcome in the simplest, most efficacious, most pleasant, and most physiological manner. It simply amounts to this: the last item in the menu should be dessert, not sweets. This is physiologically correct, whether we are concerned with oral or stomachic digestion. Uncooked fruit in the routine dietary should be looked on as a *sine qua non*—at least, in the last meal of the day. The amount of fruit indulged in should be regulated by the amount necessary to keep the whole alimentary canal in physiological activity without the aid of medicine. It is an interesting fact that mothers who have a conscientious objection to giving medicine, and whose chief concern seems to be the lower end of the alimentary canal, have children who, as far as my experience goes, have teeth which are remarkably free from caries. I need hardly say that some fruits are better than others for keeping the mouth clean. The best is, I believe, the apple. I have been struck with the freedom from caries of those who generally eat an apple after dinner, and a few days ago I heard that a patient's relative of ninety had thirty-two sound teeth, who claims to have always eaten apples, and, moreover, attributes his good teeth to this practice.

There appears to be an idea that foods which are acid in themselves are harmful to the teeth; but clinical evidence does not support this assumption. When foods which are acid are taken into the mouth they stimulate a flow of alkaline saliva, not only while they are in the mouth, but probably even after they are swallowed. This is analogous to the fact that chronic hyperchlorhydria is associated with marked alkalinity of the saliva. Moreover, acids are inimical to the acid-forming micro-organisms, and it is just possible that the acid of acid foods tends to precipitate the mucus on those parts of the teeth which are not subjected to friction, and thus tends to protect those parts of the teeth.[9] Here I might also observe that the amount of acid fermentation which different foods are subject to is not necessarily a criterion of the amount that such foods are liable to produce caries. Thus, though bread and potatoes are much more fermentable than sugars, clinical evidence shows that the latter are more injurious to the teeth. It should further be remembered that boiled starch, though more readily fermentable by bacteria, is likewise more easily and rapidly converted by the ptyalin, and thus brought into a state which renders it likely to be quickly swallowed.

If in recent years medical men have been able to inflict a restricted, soft, alkaline, insipid, unphysiological, and even repulsive diet on the vast majority of children, is it not possible that they will in the future be able (with the aid and advice of the dentist) to impose a less restricted, less pappy, less insipid and, in general, a less disagreeable diet on future generations?

It may be remembered that the lancet was at one time the panacea for all diseases. Now, for children at least, milk, or anything which approaches its insipidity, seems to have taken its place. The infant's toothless mouth and immature stomach appear to be idolized and the teeth and alimentary canal of children and adults deprived of their normal requirements. Possibly the pap craze will go the way of the lancet.

It should be distinctly realized that "most of the delusions under which the public labors today is because its ancestors were taught by the medical men of their time. The history of medicine is largely a history of error; this, not because physicians are exceptionally stupid, but because medicine is always at the mercy of the more fundamental sciences, and these are but a growth of yesterday. Thus, it is that what was universally taught and believed only a generation ago, we now repudiate.[11]

It is not my desire to enter into argument with regard to the inflictions and restrictions which have brought about the frightful state of the teeth which we know of today.[12] I want only to indicate that the natural and beneficent instincts will rather help than hinder the prevention of decay in the teeth—i. e., of course, if the instincts, and anatomy of the child are not perverted or ruined in childhood.

Further, the theory is now believed by many to be in accord with common sense and clinical experience, and it is impossible to prevent intelligent dentists as parents from adopting the same simple precautions for the benefit of those who are nearest and dearest to them.

It is hardly necessary to add, in conclusion, that what I have said in this communication does not constitute the whole of the reform in current methods of feeding children which I advocate. It is, however, perhaps enough to show that a fair knowledge of the true principles of dietetics is as necessary for the dentist as for the medical practitioner.

Since the foregoing was written a remarkable amount of discussion has gone on in our leading medical journals, e. g., *The British Medical Journal,* the *Medical Press* and the *Lancet.* Unfortunately, however much it may have turned in my favor, it must be admitted that my views have only been appreciated and supported by those medical men and dentists who have gained eminent positions such as editors of Journals or those who have written books of outstanding merit dealing with dietetics, together with the prevention of the diseases of the teeth and the hygiene of the alimentary canal. To do so, however, let me refer back to what was taught, even so recently as 1897 in the fourth edition of what was generally known as Tomes' *Dental Surgery.*[13] Therein the author said:

> "There can be no question that the tendency to caries, whether induced by structural deficiencies or perverted functions, is strongly inherited; so strongly, indeed, that sometimes as the several children of the parent successively arrive at a certain age, the corresponding teeth will become decayed." (Second edition, 1873, p. 732.)
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> "This inherited tendency would appear to come often from one side only; thus, I am acquainted with two families in which the children by a first marriage have conspicuously good teeth, whilst those by a second have equally conspicuously bad ones. In both instances the mothers of the second families had lost all their teeth at a comparatively early age."[14]

You will observe from this quotation that Sir John and Mr. C. Tomes do not even take into consideration the fact that the mothers of the second families may have brought up their families differently as far as diet was concerned. But we cannot blame them for this, as the dietetic factor was overlooked by all writers on the subject, except, as I have said, in so far as diet was supposed to have a constitutional influence on the teeth and oral secretions. It was well known that the fermentation of carbohydrates or mixed foods gave rise to decay, but why in one case the teeth remained healthy and in another case they were riddled with dental caries was an unsolved mystery. Moreover, the dental profession scarcely ventured to suspect a system of dietary which had been introduced by the medical profession. We, in awe and reverence for the physicians, accepted their edicts and scarcely dreamed that the system of diet which they advocated with such confidence and authority might indeed be by far the most important factor in bringing about the wholesale and lamentable destruction of children's teeth. We might, indeed, have continued to believe in the wisdom of their system, and have thought that the evil results followed through ignoring their commands, if we had found any marked superiority in the teeth of medical men's children; but alas, the opposite seemed to be the case. I am not sure but that it was probably a recognition of these facts which led the Executive of the British Dental Association to invite me to read a paper on "Diet in Infancy and Childhood,"[15] for the fact that diet has an important and direct effect on the teeth was beginning to be recognized by dentists and it is being impressed upon us more and more that we, too, have something to say on diet, not only because of dental caries, but also from the point of view of other diseases due to a faulty diet which are so much in evidence and react so markedly upon the development, the arrangement, and the general well-being of the teeth.

Now let us approach our subject more closely. We have first to discuss the diet of infancy, but on this I shall be brief, because we are all unanimous on the subject. The diet of the toothless infant should be mother's milk, and until we degenerate to the levels of reptiles or amphibians, it will remain so. The substitution of other kinds of milk and all means to secure a perfect substitute is a hopeless pursuit of the unattainable. Although apparently good results may be obtained in a multitude of cases when care and science guide our efforts, yet, compared with results from mother's milk, they are failures on the whole, and an inexorable law is operative which leads to a proportionally greater extermination of the bottle-fed; and thus concomitantly to the extermination of prospective mothers born from those who have not fulfilled their maternal functions. It is but tinkering with the subject to establish the most perfect cow's-milk supply possible. It is expensive, and will always remain inadequate. It is misdirecting attention which should be given to investigating the causes which eventuated in the decreased supply of mother's milk. It is not my intention at present to enter into the question of how the environment of mothers and prospective mothers could be ameliorated, so that in reference to the performance of the most important physiological functions, the civilized woman might equal if not excel the performance of these same functions by the ignorant savage. We as dentists, however, need not be unduly concerned because environment and social customs cannot be changed all at once, even if we knew how best to do so; for as regards the children's temporary teeth at least, they are so fully formed before birth that infant malfeeding has little serious effect, and when these teeth erupt they are but rarely seen to be defective.

The next stage to which we must direct our attention is one of transition—transition on the one hand from the toothless infant to the child with a complete set of temporary teeth, and on the other from the milk diet to the solid and varied food for which the child's teeth and alimentary canal are so admirably adapted. This period of transition is most important. It will be remembered that "while the child starts life edentulous, and gradually acquires teeth, other parts of the alimentary tract in the healthy subject undergo concordant changes."

For the first six or nine months of a child's life it has been accustomed to extracting liquid from the mother's breast, and through all the ages of man's evolution nothing was mixed with this milk. When, with increasing age and concomitant changes, the first article of food was presented to the child, it was given at a different time from the sucking of the milk. I think it must be obvious that in a state of Nature it was utterly impossible to soak food in milk in order to effect the transition from mother's milk to the ordinary foods of children and adults. Moreover, there is no precedent which could in any way be interpreted as justifying the method of transition from milk to solid food which has been so universally recommended by doctors, nurses and even by pediatrists. I shall exemplify how the transition from milk to solid food has been recommended by a few extracts from a recent authoritative textbook[16] published "to aid the young practitioner" of medicine. As far as this is concerned, the author, it will be granted, is strictly orthodox. After nine months, he says, "Dilutions of the milk is not necessary . . . . Some solid food may be added in the shape of boiled bread, or porridge, or pudding. These additions must be small in quantity at first." Then when the child is twelve months old, he says, "The porridge may be made thicker and of coarser oatmeal. A little potato and gravy or half an egg may be given once a day. Soft bread and butter or drippings may be taken." Pap feeding, such as is exemplified in the above, never existed in the evolution of man or animal. I intend to limit your attention to bread soaked in milk, for it illustrates the pap-feeding principle as well as anything else, and it is the most generally recommended food for infants who are beginning to be allowed something solid in addition to milk. Now, what happens when an infant hitherto accustomed to milk is given bread well soaked in milk? The first noticeable effect is that the infant gulps down the well-soaked bread-and-milk without any attempt at retaining it in the mouth or mixing it with saliva. The starchy matter in the bread is therefore washed into the stomach without any insalivation, without any conversion of the starch, and without any preparation for digestion in the stomach. The physiological effect which the retention and mastication or gnawing of food in the mouth produces, is practically lost, and the flow of digestive juices in the stomach is correspondingly lessened. The palate is cheated, for large amounts of carbohydrates are washed rapidly past it, and instead of appreciating the amount of converted starch, or rather of unconverted starch, which the child has consumed, it craves for more of that very substance of which it has already consumed too much; in other words, it develops an abnormal craving for sugar. Further, by becoming habituated to swallowing solid food, it soon loses that automatic mechanism which arrests solid food in the mouth till it has become liquefied and prepared for deglutition. If the child coughs, chokes, and splutters, can we be surprised? If the mother, seeing this, still further is inclined to pulverize, mince, boil, and soak every particle of food before giving it to the child, can we wonder?

At a later stage, say about the thirteenth month, when the first temporary molars have taken their positions, what happens when the child is restricted to this soft diet? The previous troubles continue and the teeth get dirty and tender from want of use; later they become carious and the tenderness increases, while for the same reasons mastication is not performed, and so oral sepsis and other troubles resulting therefrom become more or less thoroughly established. The child is pronounced constitutionally or hereditarily delicate to soothe the feelings of the anxious mother, and to avert all trouble in investigating real and preventable causes.

But it may be asked, why, then, has the milk-soaked diet been brought into existence? Well, I have no doubt it is because milk was considered the most excellent food for children, but it was found that cow's milk, when it was given to children undiluted, formed large clots in the stomach, and thence consequently led to various intestinal troubles. This did not disuade those in authoritative positions from holding to their guns and still advocating undiluted milk. No, they said, soak bread in the milk so that the clots will be broken up. And if there is choking and spluttering, see that it is thoroughly soft and well broken up before the child gets it. If the child does not thrive, blame the mother for not *teaching* the child to masticate its food. Imagine teaching a child to perform a complex physiological function before it has seen a couple of summers! Imagine attempting to teach a child to masticate bread crumbs or porridge boiled and well soaked in milk.

Now, why should we not take a hint from Nature? Mother's milk, when the child reaches nine months or a year, does not become more solid, rather the reverse. Suppose we give cow's milk, why should we make it less diluted than it was before, seeing that the time is beginning to approach when the child will and can eat solid food and drink liquid water? The child has been accustomed for all the months it has existed to have its mother's nipple in its mouth (or an artificial substitute), and from this it has been able to express or suck liquid food. When it is determined to give the child solid food, why not let it get a solid piece into its mouth? In other words, why not let it have half a slice of bread, or, better, perhaps, toasted bread and butter? No doubt the child feels that toast and butter is not its mother's breast, and it certainly subjects the toast to the influence of its teeth. It gnaws it and sucks it; the gnawing induces a flow of saliva, and the ptyalin converts the starch. The child continues to suck much as it sucked its mother's breast, and its palate appreciates that it is actually sucking liquid out of the solid toast. Gradually the toast disappears, practically in the form of liquid down the child's throat, thoroughly prepared for further digestion in the stomach. Before the fourteenth month, or at least before the first temporary molars erupt, true mastication, of course, is not performed. It is gnawing which is indulged in, and it certainly is indulged in by all children. Should they not be given the chance to gnaw solid food, they will pick up the pieces of stuff they find on the floor and gnaw and suck them instead, unless they are supplied with a "comforter," which is perhaps nearly as bad and generally quite as dirty.

After the child has had its toast to supplement its milk diet, say twice a day for a month or two, then other things may be added, such as rusks and milk puddings made sufficiently solid, and as there is not an excess of albumin in the milk (it having been diluted), boiled fish and chicken may be given in small amounts.

I have had some little experience of this method of feeding infants, and I can say from this experience that the desire for hard food remains. The teeth do not become tender nor the mouth dirty and the teeth carious. The palate is not cheated, and the desire for excess of food or sweets does not exist. The alimentary canal performs its functions in a natural and healthy manner, and by the age of two and a half years, when it has its full set of temporary teeth, the child can and may be allowed to *eat* practically any food which adults habitually *swallow.*

Before going further, I must ask you to forgive me for passing over the subject so quickly. I am, of course, conscious of omitting a great deal.

With regard to the diet of children after they have their twenty temporary teeth, I will say but little. The principles on which it is based, however, are the result of careful inquiry, experience, and a study of the evolution of man and his diet, together with a recognition of the needs of civilized life.

It should consist of three meals daily, and nothing between meals except water when desired.

It should contain a sufficiency of solid food of a consistency which will stimulate the pleasurable activity of efficient mastication so as to prevent the child acquiring the habit of bolting its food. Different ways of doing this will no doubt suggest themselves, but perhaps the simplest way is to have toast, baked bread, or crusty bread rolls, instead of soft bread or porridge.

Lastly, the meal should be *arranged* physiologically. All that I will say on this point, however, is that the meal must not terminate with concentrated and easily fermentable carbohydrates which lodge or stick about the teeth. Thus, therefore, no meal should end with bread and marmalade or jam, nor should it end with sweet milk puddings or foods with a large amount of sugar. If these things are eaten they must be followed by fresh fruits, and of all the fresh fruits which clean the mouth and teeth, the apple is the best.

You will see from the above that after the child nas twenty teeth, I advocate practically no restriction in diet. All that is required is a recognition of the best custom and instincts. And this is but little more than to observe the necessity of having method in the arrangement of the meal. For a healthy child, any special restriction in quantity or relative proportion of proteid is, as a rule, useless, if not harmful. Suppose we were able to know the exact quantity which is best for any particular child, and suppose we weighed it. Suppose we did not let the child choose the relative amount of proteid, carbohydrate, fat, etc., but had it all scientifically measured beforehand. Would the child be any better or happier for the care bestowed upon it? I doubt it. I do not know the origin of the belief in "the importance of the infinitely little"; and notwithstanding its prominence in recent investigations, my belief is that the exact number of ounces which should be consumed is of quite second-rate importance to the recognition of those conditions which eventuate in a pathological craving for an excessive amount. And here let me again refer to sugar. I have to indicate how the pathological craving for excess of sugar results from restricting the diet to pap. It may be that in this particular case, however, there may be other good reasons for limiting the amount which children may be allowed. For except in quite exceptional cases, sugar is not found in nature concentrated or *en masse,* but appears almost always as a flavoring highly diluted and associated with vegetable acids, cellulose, etc. That in such forms it is altogether desirable, I have no doubt. But sweets, jams, marmalade, etc., are, as it were, new articles of diet, and if, as appears, their effect on the alimentary canal is as harmful as it is in the mouth, then surely there is justification for limiting the amount. It may be said that according to a similar argument, overeating must always have been controlled to a certain extent in a state of nature by the difficulty in procuring food. This probably applies to adults, and when work is absent overeating does no doubt step in; but in the case of children there is a difference, for their ceaseless activity is their work, and the supply of food to them has always been proportional to the exertions of the parents rather than to their own. The only work that has been demanded of children throughout the ages, which has been proportional to the amount of food consumed, has been the work of masticating it. The modern pap-fed child, however, most generally has his food masticated, as it were, for him, often predigested in part, pepsined, and pancreatized. Recognizing the advances of medicine and the value of animal secretions, recognizing also that undiluted starch plays an important role in the causation of dyspepsia, how long will it be before tough ptyalin "tabloids" will be introduced procured from the mouths of State-inspected pigs under strict medical supervision?

It may be asked, what do physicians think about our system? Well, some take up a noncommittal attitude.[17] Others, like Dr. H. Campbell and Dr. Stewart Tidy, advocate it strongly. Even those who were certainly not enthusiastic when they first wrote upon the subject have come to uphold it and to recommend it not only in the prevention of disease, but also in the treatment. Thus Dr. G. A. Sutherland, in his recent work on the *Treatment of Disease in Children,* when dealing with the treatment of abdominal tuberculosis, says:

> "The natural tendency is to put such cases on a 'sloppy' diet, milk, bread-and-milk, and pudding. Experience has shown that this is the worst possible form of treatment."[18]

I must frankly admit, however, that most physicians have yet to learn how ludicrous and unscientific their graduated pap system really is. Moreover, the rank and file of the medical profession know nothing about the hard-food system of feeding children, and would perhaps be thunderstruck to hear that the "scientific pap system" which *they* were taught could ever be questioned. But we must remember that it has been difficult to reach the ears of physicians, for although we scan what is written in medical journals, few physicians trouble to read a dental journal. In fact, I have never heard of a single medical man sufficiently interested in the teeth to subscribe to a dental magazine. Moreover, it is not our lot to be able to speak from positions of eminence and authority. Professorships do not exist for members of our profession, and influential positions are conspicuous by their absence. We must therefore rely solely on the marshalling of our facts, the force of our arguments, and the overwhelming importance of our cause.

The main trend of modern dietetics has of late years been sickly and artificial, and if we can form an opinion of its general effect by the results which we see on children's teeth, then indeed it has been disastrous, for from 95 to 100 per cent of children at the age of five or six have diseased teeth, and the average number of decayed teeth in each child's mouth at that age is about nine. (And this, be it remarked, in spite of general hygienic improvement and the fact that among the better classes at least the toothbrush has been much more frequently used than it formerly was.)

Now, we have a mission to perform; it may be difficult, it may be gigantic, but it must and shall be done. First, we have got to show the medical profession the wholesale ruin of the teeth with concomitant and resulting diseases. Whether they admit that it was their system which was the cause or not, we must at least get them to realize that they are *very largely responsible* for the state of the teeth as we find them today. If they can devise a system which will excel that which we have referred to, let them do so. If they see error in it, let them criticize. We have always been willing to listen to the medical profession; we honor it for its achievements in the past, and rely assuredly on the fact that its authority can and will effect the necessary changes for the prevention of almost unlimited and unnecessary suffering.

Then we shall have to work to undermine the power of those who, taking up the erroneous teaching of the past, are spending millions annually in foisting their products and their seductive literature on an unduly trusting public. Much more which will suggest itself has to be done. One thing, however, is certain. Great things can be done by the dental profession. Sir William Osler has said that if he were asked to say whether more physical deterioration were produced by alcohol or defective teeth, he should unhesitatingly say defective teeth. This is, I believe, the opinion of those who have studied the question, and however difficult it may be to prevent alcoholism, fortunately, defective teeth may usually be easily prevented. But even if we are only able to reduce dental and correlated diseases among children by 50 per cent during the next twenty years, more good may thus be done, and more suffering averted than has resulted from the triumph of antiseptic surgery. For whereas the teeth are at present a trouble and sometimes a very real pain almost from the cradle to the grave, and while these troubles are common to almost all, and the more remote results both frequent and serious, the benefits of antiseptic surgery are fortunately limited to rare occasions in life. However this may be, there is a field in the prevention of the diseases of the teeth which promises a most fruitful harvest. We have all had a liberal education, and may be trusted not to wander into the realms of faddism. We have all got patients to see daily, and therefore will not be inclined to let our theories be uncontrolled by a recognition of facts. Indeed, all we have to do is to apply ourselves with persistent and unflinching determination, and some day the results of our work will inevitably follow.

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# Chapter XI

## AUTHOR'S EXPERIENCES

When I commenced this series of communications it was my intention to keep to a chronological sequence; but it is not altogether easy or satisfactory to do so while following the history of certain ideas which have developed during two or three decades or even centuries.

Scurvy is now generally regarded as a "deficiency disease", since it has long been known to be so liable to break out when no fresh vegetables or fruit are available. Even now, however, it may be said that there is still a controversy as to whether deficiency diseases result from absence of vitamins or from absence of firm, fibrillar-cellulose and vegetable acids, one of which has been called ascorbic acid.

My past and present views on the subject may well be indicated by reiterating the words of an eminent American research worker, Dr. Percy R. Howe; when in September 10th, 1923, he read a paper at the First Annual Meeting of the Defensive-Diet League of America in which he extolled my precepts by "recommending foods which cause the teeth to be vigorously used . . . " Likewise he called attention to the fact that:

"The use of any organ is necessary for its development. Disuse means atrophy. The cleansing effect of the fibrous food is evident, and induces firm gums and general well-being of the mouth. But just as the roughage of the food acts in the mouth, so does it act in a more important manner for systematic health in the intestinal tract. Here it keeps clean the intestinal absorption walls and strengthens the muscular tone. It prevents stasis and gives bulk to the food mixture, which indicates that more good is received from the food taken, among which is calcium. In an experimental way this is markedly shown, for animals that have intestinal derangement respond very promptly to the use of filter paper, which of course is pure cellulose."

Cellulose and vegetable acids are no doubt what may be called "accessory foodstuffs" (to use Huxley's words) but the physical consistency of food is not a vitamin, nor is it an "accessory foodstuff." Nevertheless, the firm and fibrous consistency of foodstuffs (with or without acid) may well be called an "accessory food factor" which tends to stimulate mastication and insalivation, as likewise does the dryness of food.

In 1904, I referred to the effect of firm fibrillar food in stimulating the growth of the muscles of mastication including the tongue,[2] and later to the effect of pressure strains on the development ot the jaws and other bones associated with mastication.[3] Recognition of accessory foodstuffs was certainly made in Huxley's *Lessons in Elementary Physiology* published in 1900 but the distinguished authorities who revised the fifth edition of Huxley's textbook took no notice of "accessory food factors," although "as far back as 1881 Lunin found that whereas adult mice could live for several months in good health on a diet of milk, they invariable died within a month if they received a ration composed of what he believed to be the essential ingredients of milk, namely caseinogen, milk-fat, milk-sugar, and the ash of milk. Commenting on his experiments he remarked:

> "Mice can live quite well under these conditions when receiving suitable foods (e.g. milk) but, as the above experiments demonstrate, they are unable to live on proteins, fats, carbohydrates, salts and water, it follows that other substances indispensable for nutrition must be present . . . In spite of the fact that this conclusion was given considerable publicity in the widely-read pages of Professor Bunge's *Textbook of Physiological and Pathological Chemistry,* it did not appear to have attracted the attention it merited."

It would also appear that Sir Gowland Hopkins was not acquainted with Lunin's, or Pekelharing's (1905) observations before the year 1906 though it is possible that he may have been reminded of them when my book entitled *The Rôle of Modern Dietetics* was published in 1905, and followed by remarkably laudatory reviews during the latter half of the same year. At all events it was in 1906 that Hopkins wrote as follows:[5]

> "No animal can live upon a mixture of pure protein, fat and carbohydrate, and even when the necessary inorganic material is carefully supplied, the animal still cannot flourish. The animal body is adjusted to live either upon plant tissues or other animals, and these contain countless *substances* (my italics), other than the proteins, carbohydrates, and fats."[1] I need not make further comment.

As this series of communications has already been rather long, it seems desirable to limit my remarks to giving little more than the titles of articles and discussions thereon, during, and following, the year 1907. Resulting from a courteous invitation to deliver an address at the Premier Congrès Français de Stomatologie in 1907, I willingly did so. It was entitled "Quelques Considerations sur l'Hygiène Buccale en tant que Mèdècine Prèventive." In the discussion which followed, Dr. J. Ferrier, a Vice-President of the Committee of Organization, was in the chair, and thanked me for my "interessante communication" but added "je me permetrai, cependant de lui faire quelque observations," etc. which amounted to saying, it is impossible to admit that we could give up the use of the toothbrush and he was rather dogmatic in what he said.[6] This was not altogether encouraging.

However in 1908, to draw attention to a more rational way of looking at the subject, I accepted an invitation to read a communication at the Congress of the Royal Sanitary Institute of Public Health. This duty took place, and the title may indicate the contents of my address—viz. "Observations on the Dietaries in Boys and Girls Schools, with Special Reference to the Teeth." It seemed to be much appreciated and this was decidedly gratifying to me, as it was particularly desirable that members of the medical profession who were especially interested in hygiene and public health should be acquainted with the contributions which had been made with regard to the sanitary condition of the mouth and alimentary canal.

The next indication of appreciation was obvious in an invitation sent me to read a paper at the Sixteenth Congress of Medicine which in due course was held at Budapest in 1909. This was accepted, and the address was duly published in the "Compte Rendu" 2nd Fasicule. Section XVII. There was a varied discussion on it to which I need not refer. However, it was highly encouraging for me to find at the meeting that I had been elected a President of the Section of Stomatology, of this International Congress of Medicine. The title of my paper was "Observations on the Prevention of Dental Caries." It was delivered in English and translated later into French by Dr. A. Mabille of Brussels. This French translation was sent to me presumably because at that time I was one of the secretaries of the Association Stomatologique Internationale; but I have not seen the translations into Hungarian, German and Swedish which I understand were made.

Toward the end of the nineteenth century the late Dr. James Wheatley became greatly concerned about the shameful state of children's teeth in England, and being Chief Medical Officer of Health in the County of Shropshire, he had amble opportunity to study the conditions which might have caused this alarming state of affairs. I do not suppose that it was in any way particularly different from what was found in the other counties in England, but he got to work, and with his assistants, including qualified medical men and dentists, brought forward many important observations, and especially statistical facts, which are unfortunately seldom referred to even in this country.

For this reason, and the light it throws on questions relating to the causation of dental caries, it may be well to make a few quotations to show how strenuously he advocated what we may now call the newer knowledge of hygiene in diet. In his third annual report (1910) as County Medical Officer of Health of Shropshire he says with regard to *Teeth*—[7]

> "Certain alterations have been made in recording the results of the inspections . . . so that they can be subsequently classified as desired."

I need not give the figures in which he discloses the number of decayed teeth per child in attendance districts at inspections, during May to December 1910, nor to the great amount of work done by Dr. Wheatley and his staff with regard to his statistical investigations and figures. It will suffice to give his own observations on the number of carious teeth per child in sixteen attendance districts which were inspected in his country during these seven months, May to December, 1910. The figures in the tables he gives, though striking and numerous, need not be given. I shall only refer to his summary in which he says:

> "These figures are very remarkable, particularly as they were made without a probe or mirror, and consequently the actual amount of caries must be to some extent in excess of the amount recorded. It will be well to call attention to certain points in the tables. Over 90 per cent of the children had one or more decayed teeth, and over 25 per cent of the children had 7 or more decayed teeth. Instances of 15 or 16 decayed teeth at the age of 5-6 were not at all uncommon, and occasionally children of this age were found with 20 decayed teeth. In town schools, 45 per cent of the boys, age 5, and 40 per cent of the girls, at the same age had seven or more decayed teeth.
>
> "The condition of the teeth although bad in the country schools was worse in the town schools. The figures in fact show a most deplorable condition of things."

Continuing he says,

> "That decay of teeth has increased to an enormous extent during the last two or three generations does not admit of doubt. This fact can be confirmed by almost everyone whose knowledge with respect to his own family extends over three or four generations. It is also common knowledge amongst dentists of long experience, and is proved by the comparatively small amount of caries in museum skulls of 100 years ago."

Further on in his report he says:

> "The evils arising from carious teeth, septic conditions of the mouth, and insufficient mastication of food have been dwelt upon in previous reports. In my opinion more improvement in public health can be obtained by efforts directed to abolish these conditions, than in any other line of action. It is a matter affecting not only Education Authorities, but all bodies responsible in any way for the public health, and should be looked upon as such.
>
> "The object we should strive after, is to arrest this development of caries in the present generation so far as possible, and to see that the

children of the next generation are brought up in such a way that caries will only develop as an exceptional and abnormal condition.

"The problem being such an important one, far more important than any other associated with the medical inspection of school children, it will be well to consider it in some detail. This will be done under the following headings:—

1. The causation of dental caries.
2. How it can be prevented.
3. The measures already being taken.
4. Further measures suggested.
5. The question of conservative dental treatment.

"*Causation of caries.*—Amongst much that is debatable it is, I think, universally recognized that the first step in the production of caries is the solution of the enamel of the teeth by acid. It is also generally recognized that this acid is produced solely by fermentation of carbohydrate food retained in contact with the teeth. It follows, therefore, that if no carbohydrate food is retained in contact with the teeth, there will be no caries. It does not follow that there are no other conditions which may favor the action of acid when formed, e.g., constitution of the tooth, alteration of secretions, etc. These are matters about which there is some difference of opinion.

"The primary causes of caries are therefore those conditions which favor the collection and retention of carbohydrate food about the teeth. They appear to be:—

1. Irregularities of the teeth, or a crowded condition of the teeth.
2. Defective habits of mastication.
3. Soft, sticky character of the diet.
4. Possibly defective mouth secretions.

"*How caries can be prevented.*—Granted that these are the essential causes of dental caries, the first step, in the prevention of this condition, is to take such measures in infancy and childhood as will procure a regular arrangement of teeth.

"For this purpose we must get a good development of the jaws, so as to allow of sufficient room for the teeth without crowding.

"Proper development of the jaws can only take place, if they are sufficiently exercised during the period of their growth. Free movement of the jaws in mastication, together with the pressure of one jaw against the other, tends to broaden the arches of the jaws, and provide room for the teeth. At the same time the muscles of mastication, of which the tongue is perhaps the most important, become well developed with the exercise. A well developed tongue, by exterting a constant outward pressure upon the jaws tends to broaden the arch, and to prevent irregularity of the teeth. Obviously this pressure cannot be exerted if the mouth is habitually open, and for this reason amongst others, it is very important that mouth breathers should have special attention.

"If a regular set of teeth has been produced by proper feeding in infancy, and if proper habits of mastication have been formed, it will then be possible to keep the teeth free from deposit of carbohydrate food by a certain amount of care and intelligence in eating. The fundamental truth must be recognized that the teeth can be kept clean by the food eaten and in no other way. There can be little doubt that the comparative absence of caries amongst savage races is due to the cleansing effect of their food, and it is because our food in general has lost a considerable amount of its cleansing character, that some thought is necessary in arranging our diet.

"The special reasons why sweets are so harmful is that they are so frequently eaten between meals, or last thing at night, unaccompanied by any cleansing food, or as the last part of a meal. Under these conditions, the crevices of the teeth are left partially filled with a sticky substance that rapidly undergoes acid fermentation, and attacks the enamel of the tooth. The harm done by this indiscriminate eating of sweets is so great, that very strenuous efforts should be made to put a stop to it."

One further quotation from Wheatley's report may be given, (p. 37). It refers to *Hardness of Water,* and reads as follows:[8]

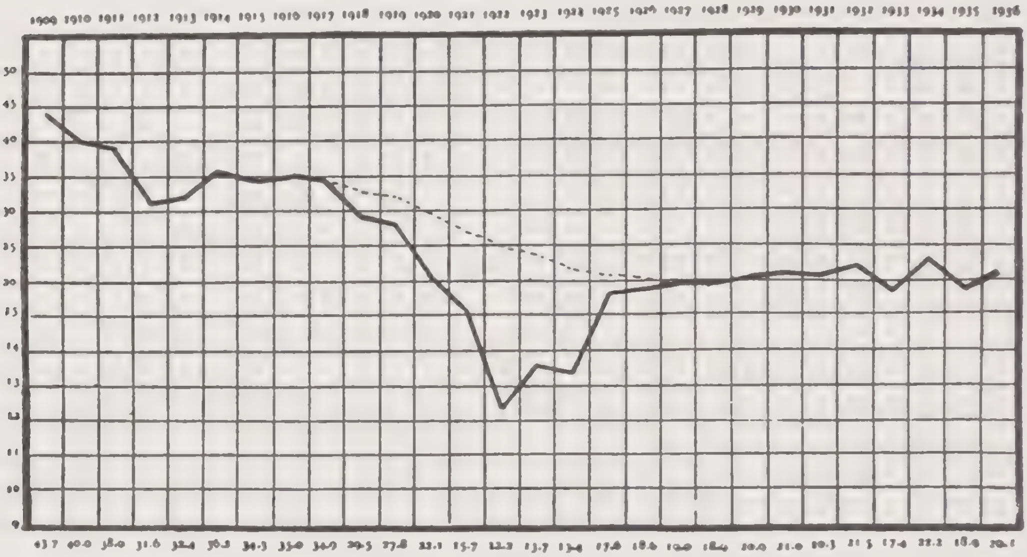
"Although there are no complete statistics available at the present time it is quite evident from the information we already have, that dental caries is extremely prevalent, even in those districts where the water is very hard. For example, the children at St. George's Church of England School, until the last 12 or 18 monthes, got their water almost entirely from two colliery supplies. Both these waters are very hard, and one contains 40 degrees of hardness, yet the average number of carious teeth per child at the last inspection was at age 5, 6.3, and at age 12, 4.1.

"The idea that deficiency of lime water is a cause of decay of the teeth dies hard, but there is absolutely no proof of such contention, and on the other hand almost conclusive proof that the hardness of water has no influence whatever."

Further comments on the work of James Wheatley will be made when we come to consider the effect of diet in England during and after the first world war. By way of a prelude however, let me give a chart kindly sent me by W. Baird Grandison L.D.S., Edin., in his report as Borough Dentist to the Education Committee of Cambridge for the year 1936. He kindly gave me permission to use it as I liked. In a way it is more telling than Dr. Wheatley's figures in his report for 1910 as it extends from 1909 to 1936, while Dr. Wheatley's figures were interrupted for a few years during the first world war (1914-1918).

It may be thought that it is hardly necessary to continue the discussion on the causation and prevention of dental caries, since as was noted in the previous chapter of this series of communications, Sir Frank Colyer virtually accepted the implications involved in the denial of the inheritance of acquired characters (1908),* and otherwise framed his rules for the prevention of caries (in 1910)** on the chemico-parasitical theory as established by W. D. Miller, and as Sir Frank Colyer was then recognized to be the most authoritative teacher in England and remains so to the present day, surely it was time to get on with the campaign of prevention by those who were interested in a task of such extraordinary importance.

However, the old theory of the structural deficiency of the teeth and their associated lack of resistance to disease, like many other theories, dies hard. As, however, the simple truth is widely known, it will sooner or later become accepted, except at first perhaps by those who profit in useless research, and the many diseases resulting from thoughtlessness and lack of common sense. It will no doubt be useful and congenial to many to follow the history of our knowledge and its successes during the four decades which have elapsed since 1910.



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# Chapter XII

## A REVIEW OF THE LITERATURE FROM 1911-1920

In 1911, an epitome of my earlier views was given in a booklet of forty-five pages entitled, "The Prevention of Dental Caries." This was translated and republished in the *Svensk Tandlähare Tidskrift* (1912).[1] But it is not necessary to make reference to my views during the first decade of this century as these have, I hope, been sufficiently recalled in previous articles in the *Dental Items of Interest* and other well-known journals. I should, however, like to make a few quotations from the Preface to the first edition to Professor H. P. Pickerill's book on the *Prevention of Dental Caries* which appeared some considerable time after the first edition of my book on the same subject was published. In the Preface of Pickerill's book it was stated that:

> "a plan of campaign was drawn up to which it was decided to adhere, and to continue the work until the whole field had been covered or at least investigated to some extent. It was further decided to publish nothing until the chain of evidence was more or less complete . . . This has obvious disadvantages, one of which is the length to which the subject has grown, and another the fact that *in several matters the results have been forestalled in publication by others working along similar lines.*" (Nov. 1911. Italics mine.)

I had heard that Pickerill's book was going to be published, but was unable to get a copy till February 1912. Pickerill's book attracted much attention, both in England and America. In the December number of the *Journal of the Allied Societies for 1912*, an address by Professor Wm. J. Gies was recorded. In his observations he restricted his remarks to what he called a discussion of one of the most important and far-reaching of the recent studies of dental caries (*The Prevention of Dental Caries* by H. P. Pickerill).

Unfortunately, when Professor Gies delivered his address he was not aware of the antecedents of Pickerill's observations and experiments, and obviously Dr. Gies had never seen nor heard of the books which had forestalled Pickerill's work on the *Prevention of Dental Caries and Oral Sepsis.*

Reviews of my first few books,[2 3 4] to which I have just referred, showed much appreciation of my conclusions. So I decided to send Dr. Gies the books I had written during the eleven years preceding the publication of Pickerill's book. In due course the December number of the *Journal of the Allied Societies for 1913* arrived and I was glad to see that a communication entitled "A Further Study of Dental Caries" by Drs. Lothrop and Gies was published, in which Dr. Gies referred to the fact that suggestion and data on the prophylactic use of food-acid were made by Wallace prior to their own and Pickerill's proposals on the subject.[5]

What followed may best be indicated by referring to the first of some "Selections" in the *Dental Record* for April 1914. It was entitled, "A Further Study of Dental Caries by Alfred P. Lothrop and William J. Gies,* and read as follows:

"A year ago the senior author[6] restricted his remarks to a consideration of one of the most important and far-reaching of the recent studies of Dental Caries and Oral Sepsis."

It was the speaker's intention of confining his remarks to Pickerill's work among others deserving of attention, to convey through this journal, to its many readers, the most interesting and important opinions and findings in Pickerill's views on the virtue of acid ingredients in the diet.

It was said that Pickerill

"states conclusions which not only support the proposed use of fruit and vegetable juices, etc., as dentifrices, but which also indicate a larger usefulness of such 'natural acids' as essential elements in a *prophylactic diet.* Let me quote a few of his statements on this broad view of the utility of 'food acids' and acid dietaries in the contest against dental caries."

After repeating the quotations, Dr. Gies said:

"When these concluding remarks were made by the speaker, he did not know that the quoted conclusions in Pickerill's book had previously been stated, in substance, by Wallace. It is a pleasure now, speaking from the same platform to many who were in the audience that heard the reading of these quotations a year ago, to do full though belated justice to the work and wisdom of Wallace."**

From a group of seven available books by J. Sim Wallace, M.D., D.Sc., L.D.S., issued during the period 1902-1912, inclusive, we note the following typical statements in *Supplementary Essays on the Cause and Prevention of Dental Caries,* published by Bailliere, Tindall and Cox, London, in 1906.*

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* As an additional heading to this article the editor of the *Dental Record* added: "We consider that this article does no more than justice to the pioneer work of Dr. Sim Wallace."

** Pickerill has ignored Wallace almost completely. The only reference to Wallace on these subjects that we have found in Pickerill's above-mentioned book is the following "The elimination of all fibrous elements from food, too, probably tends, as Wallace (*The Physiology of Mastication,* London, 1903) has pointed out, to the increased lodgeability of foodstuffs, by robbing them of their detergent action upon the teeth." (Page 269.)

Continuing our quotations from the book of Wallace's already referred to, we note the following among other paragraphs of special interest in their relation to Pickerill's subsequent comment:

> "If in recent years medical men have been able to inflict a restricted, *soft, alkaline, insipid, unphysiological and even repulsive diet* on the vast majority of children, is it not possible that they will in the future be able (with the aid and advice of the dentist) to impose a less restricted, less pappy, less insipid, and in general a less disagreeable diet on future generations? (Page 78).
>
> "It is not my desire to enter into argument with regard to the inflictions and restrictions which have brought about the frightful state of the teeth which we know of today. I want only to indicate that the natural and beneficent desires and instincts will rather help than hinder the prevention of decay in the teeth, i. e., of course, if the desires, instincts and anatomy of the child are not perverted or ruined in childhood. This is my reply to those who admit that I may be correct, but doubt if people would relish and adopt the proposed reform. It is suggested that the experiment should be tried on the *corpus* vile before the theory can be proved. This I have done, and the teeth are, at the age of five, absolutely free from all suspicion of caries,* and this in spite of the fact that, hereditarily, the child under consideration would have been expected to have had remarkably bad teeth, and, further, in spite of the fact that he was a bottle-fed baby. Moreover, the toothbrush and antiseptic mouth washes were not used, except occasionally after partaking of food at the house of friends. Yet, though considerably worn, his teeth are, and always have been, as white and clean as could possibly be desired; the darkest, the upper incisors, being of $B_1$ of Ash's shades. (Page 79).
>
> "Further proof is surely forthcoming, for the theory is now believed by many to be *in accord with common sense and clinical experience,* and it is impossible to prevent intelligent dentists as parents from adopting the same simple precautions for the benefit of those who are nearest and dearest to them." (Page 80).

At this point the speaker (Dr. Gies) said that this field was wholly unfamiliar to him when he began these researches four years ago, which accounted for much of the ignorance he had already revealed in these annual reports. But, just as his continuous effort to digest the literature led to his acquaintance with Pickerill's monumental work, and to his formal public statements in praise and appreciation of it, so the same endeavor brought to his attention the valuable contributions of Wallace.

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* "In a recent careful investigation into the state of school-children's teeth at that age, not one was found to have a perfect dentition; in the ninety-five children examined, 896 carious teeth were found." *(British Dental Journal,* November 15, 1905). (Quoted footnote.)

His dependence upon Pickerill's book, as a reliable survey of the field it covered, had unfortunately delayed his discovery of Wallace's views, and had thus prevented him from gaining, at an earlier date, the advantages recently derived from a study of Wallace's findings. He said he could not understand why Pickerill ignored the existence of such remarks by Wallace as those quoted above, which were largely a prestatement of important ideas in Pickerill's book that are presented there with the appearance of being original views; but he was obliged to assume that Pickerill, like himself, was unaware of their publication or else that Pickerill felt it undesirable to refer to them. If there was a good reason for the latter decision, the speaker felt it would be a public service if Pickerill would state them. But a contribution by Pickerill, in the number of this journal which was issued a few days ago, and entitled "Knowledge and Belief," was not reassuring on this point.

> "Pickerill does not seem to note the fact that recognitions of priority are impersonal in their broadest effects—they help to define the limit of knowledge; to show the sources and to indicate the reliability of information; and, through the penalties that follow discovered plagiarism and other forms of misappropriation, to prevent the demoralization of literature as well as the confusion of the records of science."[7]

In contradistinction to Professor Pickerill's attitude, the late Sir Truby King in his book, entitled *The Feeding and Care of Baby,* quoted in bold letters some of my observations on mastication, and in an address given at the Annual Meeting of the British Dental Association in 1909, he also approvingly referred to my views as delivered in 1905 before the "British Throat, Nose and Ear Society" (to Anglicize the name). Therein he quoted my observations with regard to "Mouth-breathing" as follows:

> "Nasal-obstruction is now quite a common disease, although a few generations ago it was practically unknown. This can be easily proved, because nasal-obstruction and mouth-breathing give rise to a characteristic deformity of the jaws, and to an easily recognizable irregularity of the teeth. The mouth-breather's jaw is absent in all but recent collections of skulls . . . Dr. Sim Wallace recognizes the prejudicial influence on the organism in general, and on the mouth, nose, and throat in particular, resulting from living in close, stuffy, unventilated, germladen rooms, and in passing from such poisoned, heated places into the cold air, etc. Having considered such factors, Dr. Wallace next devotes his attention to the special cause of the prevalence of mouth-breathing and adenoids in the present day—viz. the unsuitable food and feeding habits imposed on babies and young children."[8]

Then referring to an address delivered by me in 1904, Dr. Truby King quotes the following with approval from the *Dental Annual:*

> "There has been of late a remarkable consensus as to the superiority of early mastication and the general exercise of the jaw muscles . . . as compared with soft-feeding and artificial cleansing of the mouth." Continuing, he quotes my words, " . . . Dental caries is preventable, and we know enough to explain how this can easily be done . . . In conclusion I would remind you that it is not only a dental question, it is not only a medical question, it is not a national question, but it is probably the most important of all questions affecting the physical well-being of humanity throughout the length and breadth of the civilized world!"

Sir Truby King then says:

> "Dr. Pickerill, Professor of Dentistry at Otago University, confirms Dr. Sim Wallace's views. Speaking from his own experience in England and New Zealand, he finds that deformities of the jaws and palate and caries of the teeth are even more prevalent in the Dominion than at home."[9]

The question really arises, why do some research workers such as Dr. Pickerill not acknowledge the views which

> "were largely a prestatement of important ideas in Pickerill's book that are presented there with the appearance of being original views . . . ?"[10]

Surely one might think it was all to the good to give reference to the ideas upon which the pillars of the newer knowledge were based.

This apparently was my idea when the index to my book on *The Prevention of Dental Caries* was being prepared. Thus, in a footnote to the forty-seven references given in the bibliography I wrote:

> "The investigations of the late Dr. W. D. Miller with regard to the micro-organisms of the mouth and correlated subjects, together with Dr. G. V. Black's bacteriological, gnathodynamometric and chemical and physical investigations, are of quite exceptional importance in having provided data for the elucidation of the causation of dental caries."

Similarly Dr. James Wheatly, in an address read before the Salop Branch of the British Medical Association October 4th, 1910, said:

> " . . . At the outset I should like to say I am very greatly indebted to Dr. Harry Campbell and Dr. Sim Wallace, for the help they have given me in writing this paper."

The late Dr. Wheatly eventually became the president of the Society of Medical Officers of Health and the value of his work still remains unchallenged. This will be referred to later with regard to the effects on the teeth revealed in his statistical reports, etc., after the first World War. I need not refer further to the support my views have received with regard to "the unsuitable food and feeding habits imposed on babies and young children," but would only add that Sir Truby King concluded his statements by remarking that:

"Dr. Pickerill, Profesor of Dentistry at the Otago University, confirms Dr. Sim Wallace's Views, etc.[11]

The next book of historical importance to which reference must be made is entitled: *The Science and Practice of Dental Surgery,* edited by Norman G. Bennett, M.A., M.B., B.C. (Camb.), L.D.S., England. Among the thirty-five contributors to this book my name might be mentioned as having been privileged to write the chapter on "The Aetiology of Dental Caries" (pp. 282-294). Further remarks on this chapter are unnecessary, but the chapter on "Oral Hygiene and Preventive Treatment of the Dental Caries," by E. B. Dowsett, L.R.C.P., Lond., M.R.C.S., L.D.S., Eng., indicates very clearly that as far back as 1914 the theory of "The Newer Knowledge" which I have been trying to expound was corroborated by particularly eminent authorities such as Sir Truby King, Drs. Harry Campbell and James Wheatley and endorsed in the standard textbooks of Sir Frank Colyer and Sir Norman Bennett. In the chapter for which E. B. Dowsett is responsible he remarked that:

"It has been truly said that 'the mouth is the vestibule of life', and therefore it behooves dental surgeons, as the potential guardians of that important cavity and its contents, to take every possible means to keep its various functions in as thorough working order as possible . . .

. . . "The beautiful conformity and arrangement of a normal dentition indicate that the teeth were intended to be of great service to the individual; but the advance in civilization, and with it the culinary art, has lessened their use; hence the food tends to cling about the mouth and tartar to collect, and the necessity for the artificial almost invariably arises. But if it were possible to return to a dietary that necessitated vigorous mastication, the surfaces of the teeth would be continually polished by the friction of the food, and the gums stimulated to their proper function, and thus the integrity and environment of the teeth maintained in their normal conditions . . . Sim Wallace sums up the whole question in the following words: 'If children are fed according to physiological principles, while hygienic requirements are not neglected, the teeth will not decay, nor will the other diseases which result from infringement of the physiological laws be at all likely to be prevalent!"

Were it not for the gullibility of the public and the magnetic power of words which were cunningly invented "to attract public attention" and because Casmir Funk coined a new term, *vitamine,* for the substance contained in rich polishings and in the foods that cure polyneuritis in birds and beriberi in men, the craze for vitamins might never have gained currency. Funk himself said:

"I must admit that when I chose the name 'vitamine' I was well aware that these substances might later prove not to be of an amine nature. However, it was necessary for me to choose a name that would sound well and serve as a catch-word."[12]

This then became the basis of the inordinate craze for vitamins. The catch-word was based on an erroneous assumption. This was admitted and to rectify the blunder the letter *e* was deleted from the word "vitamines," but good care was taken to retain the catch-word, and Funk was well rewarded for having given a misleading word for the substance contained in rice polishings and in the foods that cure polyneuritis in birds and beriberi in man. Here we have a pretty instance of the nature of one of the chief pillars upon which the science of nutrition has rested during recent years and through which the public as well as medical practitioners have had their imagination struck.

Before concluding this chapter dealing with progress made during the second decade of this century, i. e. before the Manchester Conference on the Prevention of the Diseases of the Teeth, which included a summary of Dr. Wheatly's statistical examination of the restrictions in diet during the first World War, it may be well to note the progress that had been made by reference to the views expressed by acknowledged authorities who held eminent positions in England and paid special attention to the prevention of the diseases of the teeth. It may best begin with views expressed in the *Dental Record* of December, 1911, in which there is a review of the Fifth International Dental Congress.

Of the twelve sections reviewed, I need only refer to the one dealing with oral hygiene in which Dr. Gordon refers to the fact

> "we shall be quickly carried further back to the very beginning—so that our function may in reality be prevention rather than cure, a problem not so terribly difficult of solution . . . Let us hope coming legislation will facilitate this; dental examination of school children is a beginning, but why must these things be started at the wrong end? . . . Agreeing heartily as we do with these views, we hope that in the very near future this section will devote itself to the principle of prevention which Dr. Sim Wallace has proved in his book, *The Prevention of Dental Caries,* to be so eminently practicable and almost wonderful, nay, miraculous to the uninitiated, in its results . . . "[13]

The name of the late J. H. Mummery is well known in America. He was a D.Sc. (Penn.) as well as F.R.C.S., and L.D.S., Eng. He had the state recognition indicated in the letters C.B.E., but perhaps on account of his having written the paragraph about to be quoted, he did not receive any higher honors in England. The paragraph to which I refer reads as follows:

"Dr. Sim Wallace has been engaged for some years past in a highly important work, by drawing attention to the means of dealing with caries of the teeth of children, and the crusade against the disease on which he has embarked will, no doubt, be productive of the happiest results, if only it helps to wake up the authorities in this country, as it has to some extent, to a thorough appreciation of the fact that, at least to a very great degree, caries is a preventable disease."[14]

It seems to have been recognized that the public should know the simple facts elucidated by the leaders of the dental and medical profession with regard to the prevention of the diseases of the teeth, since it is the parents rather than the doctors who are immediately concerned with the diet and care of young children. In Metheun's Health Series, edited by Bishop Harmen, M.B., F.R.C.S., a book was first published in 1916 on *The Care of the Teeth*, by A. T. Pitts, M.R.C.S., L.R.C.P., L.D.S., Eng. On the preface he notes that the subject of dental disease is "rather prominently before the public just now. References to it are common in the newspapers, while the serious have not disdained the problem. It would therefore seem a fitting time to group together such facts as are known in a form that can be understood by the public . . . " This book of the late A. T. Pitts, who was chosen to write it, is well illustrated and easy to follow, while the authoritative position which he held as Member Board of Examiners Dent. Surg. R.C.S., and various other important dental appointments, add weight to what he says with regard to "The Care of the Teeth and the Prevention of Dental Disease" (Chapter IX) in which he begins with the words:

"It is an old adage that prevention is better than cure" and after dilating on the cause of dental caries he goes on to say: "The keynote to the prevention of dental disease is the prevention of the stagnation of sticky carbo-hydrate food around the teeth. This depends on several things: firstly, the teeth must be well shaped and of good structure; secondly, they must be arranged in broad even arches, and each tooth must be in close contact with its neighbour so that food does not get jammed between them; thirdly, the muscles of the tongue, lips, and cheeks must be well formed so that by their movements they may help to keep the teeth clean; fourthly, the teeth of the upper and lower jaw must meet in proper contact so that the food can be masticated properly, since food when well chewed has far less chance of adhering to the teeth than when it is only partly chewed; fifthly, there must be a free flow of clear limpid saliva to act as a natural mouth-wash, and to wash away any particle of food not removed by the tongue, lips, and cheeks; sixthly, the food itself must be of such a nature that it does not tend to stick to the teeth: it must be sufficiently hard and fibrous to be self-cleansing in character and to give the teeth a proper amount of work to do; seventhly, the health of the child must be good, for proper growth of the teeth, jaws, and muscles can only occur in a healthy child. Lastly, there must be an entire absence of any obstruction to nasal respiration.

"Now this may seem a somewhat formidable catalogue of ideals, and yet they are all interdependent, and obtainable not by any expensive or laborious methods but by following a few simple rules.

"For the first nine months of an infant's life the proper food for it is its mother's milk. A breast-fed child is much more likely to be healthy than a bottle-fed child, and the condition of health favours a proper growth of the whole body, including the teeth and jaws. But in addition, suckling has a specific effect on the development of the jaws. As was described in the chapter on Irregularities, the act of suckling has a moulding effect on the jaws of the greatest importance, so that at the very commencement of life we have in breast feeding a factor in causing a proper development of the jaws which cannot be replaced by any artificial method of feeding nor by any subsequent care of the teeth in later life.

When the child is weaned and the teeth are beginning to erupt, then food can be given which will need some mastication. This book does not pretend to be a manual of dietetics; the subject is only dealt with in so far as it has a bearing on dental hygiene, but it can be stated emphatically that a child of two or three years is quite capable of eating food moderately hard, and only good can come of its doing so. It is common to see parents carefully cutting off the crust of a piece of bread and butter, thus taking away the best part of it, with the idea that the crust is too hard for the baby teeth.

"The result is that the child soon gets into the habit of refusing to eat any food that needs mastication, and the habit thus formed is difficult to break. The habit of chewing the food well is of the greatest importance, since in chewing, the muscles of the tongue, cheek, and lip, and the muscles attached to the jaw, are exercised and grow properly, while a free flow of saliva results. Like other good habits, it is best formed early in life.

"With regard to the food that should be given I cannot do better than quote the words of Dr. Sim Wallace, who has devoted much time to a study of this and kindred problems:

"'During the first two and a half years of life all starchy or sugary foods (except milk) should be given in a firm and fibrous form, so as to stimulate mastication and insalivation and thus promote the healthy growth of the jaws and the regular arrangement of the teeth. Bread, rusks, or any other starchy food should never be added to or soaked in milk. Bread with crust and butter, toasted bread and butter should form a considerable part of the solid part of the meals habitually given to children of this age. As the infant passes from the milk diet to the more solid diet, the milk should be more and more diluted with water. During this period the solid food should be eaten first and the milk and water taken after.

"'After the age of two and a half years children should always have a considerable amount of the starchy food in a form which will stimulate a pleasurable amount of efficient mastication.

"'The albuminous (i. e. fleshy) part of the food should also be presented in a form which will encourage mastication; for example, boiled fish, meat, and later bacon. Milk and milk substitute should only be allowed in small amounts.

" 'The meals should be arranged in such a way that if soft starchy or sugary foods has been eaten, the mouth and teeth shall be cleansed by food of a cleansing nature taken immediately after. Thus when sweets of any kind, for example, milk puddings, jam rolls, cake, sweet biscuits, bread and marmalade or jam are eaten, fresh fruit should be eaten afterwards.

" 'Three meals daily are to be preferred to any greater number, as the longer the interval the more hygienic is the state of the mouth and stomach, and therefore the more perfectly adapted for the reception of a further meal.

" 'Sweets, chocolate, or biscuits and milk should never be eaten between meals or before going to bed.'

" 'Dr. Sim Wallace has further compiled a list of foodstuffs into the two groups of cleansing and non-cleansing which are appended.

### FOODSTUFFS AND DENTAL CARIES

| *Not Cleansing and Liable to Induce Dental Caries* | *Cleansing and Prevention of Dental Caries* |
|---|---|
| Starchy and sugary food in general without fibrous element.<br>EXAMPLES: Sweet biscuits and cake, bread and marmalade, bread and jam, new bread without crust, bread soaked in milk, milk puddings, porridge and milk, preserved fruit, chocolate, and sweets of all kinds, honey.<br>LIQUIDS: Cocoa and chocolate.<br>The above foods should not be eaten except when followed by foods of a cleansing kind. | Fibrous foods generally.<br>EXAMPLES: Fish, meat, bacon, poultry, uncooked vegetables, lettuce, cress, radish, celery. Cooked vegetables are as a rule cleansing, but in a less degree than uncooked vegetables.<br>Stale bread with crust, toasted bread of all kinds, twice-baked bread.<br>SAVOURIES: Fresh fruit, especially those requiring mastication, e.g. apples; fatty foods, e.g butter and margarine.<br>LIQUIDS: Tea (preferably Russian fashion), coffee, buttermilk, water, also soups and beef tea. |

"A study of the above rules will show that to arrange the order and nature of the food so that it should leave the mouth in a clean state does not mean any radical change of diet, nor does it involve any extra expense."[15]

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# Chapter XIII

## DENTAL HYGIENE IN INFANCY AND CHILDHOOD

Now let me revert to a debate on Dental Hygiene in Infancy and Childhood which I was commissioned to open at the Congress of the Royal Sanitary Institute held at Exeter and reported in the December 1913 issue of its Journal. I commenced by saying:

"In opening this debate on Infancy and Childhood I will refer in the first place to the general principles of oral hygiene, and after having done so will devote attention to the practical application of these principles with regard to dental hygiene in infancy and childhood.

"To understand properly the physiology of oral hygiene it is necessary to refer to the physiology of mastication, for although the chief function of mastication is the preliminary preparation of food in order to facilitate its digestion, it has a secondary function, in that when suitable foods are masticated it cleans the teeth and facilitates the action of the saliva in doing likewise. It should be noted, however, that many foodstuffs which are consumed at the present day are hardly subjected to the process of mastication at all. The food is simply taken into the mouth, receives a general squash between the teeth or between the dorsum of the tongue and the hard palate, and is then swallowed . . . "

When for any reason mastication is not performed on one side of the mouth, the teeth on that side become coated with mucus, tartar, and food *debris*. It is evident, therefore, that mastication of fibrous food is conducive to dental hygiene. Now let us turn our attention to mucus and saliva. Mucus is important as a lubricant, and, mixed with saliva, a vehicle for the removal of food particles. It lubricates the mucous membrane and teeth on the one hand, and the food on the other, thus facilitating the passage of the food from one part of the mouth to another during mastication. Being of a sticky and tenacious character particles or shreds of food are, as it were, caught or roped and pulled backwards down the throat with each act of deglutition. Thus, therefore, food of a particulate or shreddy nature is relatively easily removed from the mouth. When the food is not of a short, pasty, or viscid character, the mucus, generally speaking, insures its complete, or practically complete, removal from the buccal cavity. The mucus is, in general, secreted in amounts proportionate to the requirements of the particular kinds of foods for this purpose. Likewise the saliva facilitates the same physiological processes. and the quality and quantity secreted is also, generally speaking, proportionate to the requirements of the food consumed. Saliva has also a marked effect in preventing acids taken in food, or developed by bacteria, from decalcifying the enamel, and this effect seems to be much greater than could be accounted for simply by its power of neutralizing the acid. Mucus is freely miscible with saliva, so that even if mucus has no similar power in protecting the enamel from decalcification, it does not hinder such beneficent action of the saliva. The variations in the amount and quality of the saliva and mucus, corresponding to the quality of the food consumed, appear to be common to all, whether "susceptible" or "immune" to caries. That this is so is not a subject of controversy, but nevertheless, the fact that the normal physiological processes supply with marvelous ingenuity the means of securing the cleanliness of the mouth and teeth seems to be most persistently overlooked by many who believe that the mouth is clean, or otherwise, according to whether it has or has not been brushed with a toothbrush.

At one time it was taught that the function of the saliva was to digest starch. To a slight extent this is no doubt true; but by far the most important function of the saliva is to keep the mouth in a hygienic state. Substances which might be noxious to the teeth, if they remained for a considerable time in the mouth, are as a rule rapidly got rid of by the saliva, and in general we may say that the saliva is secreted in quantity and quality proportionate to the necessity for the removal or control of substances obnoxious to the teeth. Thus, accordingly, sugar in the mouth causes a copious flow of saliva, yet sugar is not digested by the saliva, and the rationale of the copious flow is to get the sugar of the mouth and prevent it from doing any harm. Similarly acids call forth a copious flow of saliva. If acids were retained in the mouth without dilution or neutralization by the saliva, injury might be done to the teeth. But special provision is made for the prevention of such injury, for not only does the acid call forth a copious flow of saliva, but it also tends to precipitate the mucus on the unrubbed surfaces of the teeth, which hinders the acid from doing any harm to the enamel. Over and above this an afterflow of alkaline saliva is induced, which helps to clear the mucus which has been disorganized by the precipitation of the acid, together with food particles and bacteria, away from the teeth. Then again, dry foods stimulate the flow of saliva, for their removal is facilitated in this way. On the other hand, liquids of a neutral or alkaline character do not stimulate the salivary secretions. They are easily swallowed, that is to say, passed out of the mouth without the aid of saliva. If the foods were of what we may call a natural kind, the mouth and teeth would always be clean, and the teeth would remain free from caries, as the teeth of animals do; but on account of cookery and the artificial refinement of food, the natural self-cleansing process of the mouth are frequently stultified. Thus, for example, sugar may be so concentrated as to hinder the action of the saliva; the fibrous part of the food may be so thoroughly eliminated as to make mastication impossible; while farinaceous food may be so viscous and refined, that after it is plastered into the crevices of the teeth, the saliva may be unable to remove it before injury is done to the teeth. Most vegetable foods, especially fruits, very generally associate cellulose, sugars, acids, aromatic, and even acrid principles, and it is scarcely right to consider the effects of any one of them when disassociated from the others. They naturally supplement each other in oral hygiene. Thus, while the cellulose, on account of its physical nature, is arrested in the mouth, and disintegrated by the teeth, the acid and aromatic principles stimulate the flow of saliva and help to loosen the cellulose framework. Further, the aromatic taste often remains in the mouth and continues to stimulate the flow of saliva even after the food has been swallowed. It was foodstuffs as they were presented in nature to man and his ancestry that his organization was most perfectly adapted, and it does not necessarily follow that a concentrated extract of any such food is necessarily harmless to the teeth, or even the mucous membrane of the mouth.

As far, then, as the teeth are concerned, a physiologically correct meal requires, firstly, that it should contain a reasonable amount of food of a firm or fibrillar nature which will necessitate efficient mastication, and thereby remove all bacterial plaques or masses from the masticating surfaces of the teeth; for if bacterial plaques or masses are allowed to remain on the masticating surfaces of the teeth, viscous or finely ground carbohydrate food would tend to lodge in the crevices of the masticating surfaces and so induce dental caries. Secondly, a physiologically correct meal should terminate with some foodstuff which is of a detergent nature or, at least, not liable to lodge in the crevices of or between the teeth. For this purpose we are limited to savories, to pulled bread with cheese and celery, followed by water or some more refreshing drink, preferably slightly acid and aromatic, or to fresh fruit.

Notwithstanding these alternative terminations, it will be found in practice with numbers of children that the best and most suitable termination, and the termination which children most relish, is fresh fruit. Nothing is more conducive to the hygiene of the mouth except, perhaps, raw vegetable foods, so that fresh fruit should practically always form part of the routine dietary of healthy children, and after fresh fruit has terminated the last meal of the day (which should not be taken just before going to bed) nothing should be allowed except water.

In considering what is necessary for the prevention of dental diseases in infancy or childhood, several other considerations besides oral hygiene require to be taken into account, such as, for example, that the development of the jaw should be sufficiently effectually stimulated to insure the possibility of a regular arrangement of the teeth. Inasmuch, however, as the rules requisite for the maintenance of oral hygiene do not essentially differ from rules which might be made for the stimulation of the healthy development of the jaws and alveolar processes, further reference to these subsidiary questions need not be made.

I have already given the four important rules which clearly indicate the practical application of the physiological principles noted in the earlier part of this communication, and in a previous chapter have given A. T. Pitt's endorsement of them. Here I would only allude to a postscript or paragraph which arrested the attention of those who know the value of truth. It reads as follows:

> "When those rules for the prevention of decay in teeth cannot be observed, some attempt should be made with a small tooth-brush to clean the crevices of and between the teeth after every unhygienic meal, but as this is extremely difficult to do effectually without injuring the teeth or gums, it is advisable to have children, who are brought up in this way, taken regularly to the dentist from the age of three onwards every six months, till the teeth become crowded and irregular; thereafter the visits may require at times to be more frequent until all the natural teeth have been replaced by artificial substitutes".

Continuing the discussion, Dr. James Wheatley (Salop County Council) said:

> "That presumably the work of public health authorities was to safeguard the public health and improve the physical condition of the people. This broad statement, which everyone must admit, appeared to have been to a great extent lost sight of in this connection. He ventured to say that there was no physical defect or disease that was producing so much ill-health and physical unfitness as dental caries and oral sepsis, and at the same time that its cause was well understood and its prevention a comparatively simple, although laborious matter. Under these circumstances one would have expected that every medical officer of health in the country would have been exerting himself to get rid of these conditions. He had searched the reports of the medical officers of health without finding any reference to this matter, and so far as he could ascertain no action whatever was being taken by them. In the county of

Salop, out of 4,000 children examined in the year 1912, at the age of 5-6, no less than 1,100 had ten or more decayed teeth. The condition was a disgrace, and if energetic action was not taken, public health authorities would deserve the censure of future generations. He advocated education of mothers by health visitors, of school teachers, and through them of school children, of nurses and midwives, and last, but not least, of the medical profession."[1]

Nine other speakers took part in the discussion but I need not refer to them as the main point of my paper was apparently not appreciated by them. Fortunately, Dr. Barlow (Wallasy) said nearly all I might have cared to say had I troubled to reply to irrelevant talk, since as reported:

> "He thought the debate had gone on a line different from that which the reader of the paper intended, which was not so much the care of the teeth by conservative dentistry, but by so educating the people as to render the dentist unnecesssary or nearly so. The measures advocated were very simple, so simple indeed as to render an extensive trial imperative; they practically consisted of one thing, the use, generally speaking, of harder food, and finishing up with an apple. Was it not better to prevent consumption than to have to cure it? It was likewise better and cheaper to prevent dental caries than to employ an army of dentists to imperfectly repair the injuries to the teeth which should never have appeared."[2]

Although my efforts to show that, with regard to the diseases of the teeth, prevention is better than cure fell on many deaf ears some of the more influential medical officers of health seemed to hear my call for action and I received more requests for a paper on the prevention of the diseases of the teeth than I cared for. However, I willingly responded to some, and will pass on to one of the most important. This may be indicated by an editorial article in *The Journal of the British Dental Association* on April 2nd 1917 which reads as follows:

> "We publish in this issue a paper by Dr. Sim Wallace, to which special interest attaches.[3] The Health Committee of the Birmingham City Council have for a long time been concerned to do more to prevent dental diseases among the children of the city. Mr. Joscelyne, the Honorable Secretary of our Central Counties Branch, was approached, and at his instigation Dr. Sim Wallace was asked to go down to Birmingham to deliver a lecture to the Public Health Workers of the city. At the termination of the lecture a pamphlet entitled 'The Care of Children's Teeth', which had been compiled by Dr. Sim Wallace and issued by the Corporation of Birmingham Public Health Department, was given to those who had attended the lecture. This action of the City Authorities marks an important advice, for it is a step beyond and before the school clinic; it represents a definite effort to combat dental disease by prophylactic means. Birmingham has one of the most efficient organizations for treating dental disease in the country, comprising a regular system of dental clinics, eight in number, covering all the wards of the city. The fact that

the utility of these clinics has been such that the Health Committee should have decided to take this further measure to check the ravages of disease in the mouth is a tribute to the work which our colleagues have accomplished in these centres. It is further gratifying that the Medical Officer of Health, when he desired a lecturer for this purpose, should have consulted the local officials of the British Dental Association, and that thus the services of the greatest living expert in this branch of knowledge should have been secured for the writing of the pamphlet and for the purpose of the lecture. The booklet upon the care of the teeth is one for which we desire a large circulation, since within the compass of eight small pages it gives a clear account of the main facts relating to the prevention of dental disease. Commencing with a brief explanation of the importance of the teeth, and an outline of the process by which the decay is brought about, the writer passes on to a fuller acount of foodstuffs in relation to the teeth, and gives directions as to the ordering of the diet and arrangement of the food during the meal. The early care of the teeth by operative measures is unquestionably of the greatest importance, and will doubtless for many years continue to form an essential part in the care of the child's health by the State, but a new and better way will appear when the prophylactic propaganda begun in Birmingham is more generally adopted."

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# Chapter XIV

## EXCELLENT RESULTS

In his book on *The Micro-organisms of the Human Mouth,* W. D. Miller, D.D.S., M.D., Professor at the University of Berlin made the following statement in 1890.

"The fact that decay of the teeth is of parasitic origin having been once established, the thought suggests itself that we ought to be able by means of properly chosen antiseptic materials not only to arrest decay, but to prevent its appearance. This is, indeed, the avowed object of the very many antiseptic mouth-washes now in the market. As a matter of fact, however, there is no evidence that anything whatever has as yet been accomplished in the prophylactic treatment of the teeth through the use of antiseptic mouth-washes, and it is evident that anyone who would discover some means by which the often fatal ravages caused by decay of the teeth might be held in check would thereby confer a great boon on humanity" (p. 225).

Since this was written by W. D. Miller various suggestions have been made with regard to the control or prevention of dental caries, but these did not receive much practical approval. It was not till January 1908 that anything of substantial importance was published when J. F. Colyer read a paper[1] and referring to London alone said—

"It is computed that there are something like one million school children, and of these probably 90 per cent require treatment—and you will have some idea of the magnitude of the task." Continuing he said the only remark he would make was, "that on looking at the problem . . . I am convinced the only method of tackling the question is by concentrating attention on the prevention of disease, not so much by instruction to the children as by instruction to the parents."

On the following page (*op. cit. p.* 34) he refers very approvingly to my views that the ridding of the foodstuffs of their fibrous parts by methods of preparation renders them more liable to lodge about the teeth is probably a most important factor" . . . However, after much discussion on Mr. F. J. (now Sir Frank) Colyer's paper I said there seemed to be no unanimity of opinion that it was possible to bring up children without a speck of decay in their teeth. Yet it was easily possible. There was only one way to prevent children fearing the dentist, and that was to bring them up in such a manner that they never required to have a single tooth filled. It was his, (i.e. my) conviction that it was absolutely unnecessary for decay to appear in any children's teeth if they were brought up physiologically from the beginning and given hard food at an early age as was recommended in Mr. Colyer's paper[2] (p. 73).

Time passed and in 1913, knowing that a paper was going to be read by T. G. Read, L.D.S., on "Bread in its Relation to Dental Caries," I exhibited a boy (my elder son), aged nearly twelve, with a perfect set of teeth, who, as I said, "for the last eleven years had been brought up according to the system which was going to be condemned that evening in a paper by Mr. Read. With the exception of two or three months during the *Daily Mail* Craze, the boy had always eaten white bread. Now and again, as a trial, stone-milled bread had been used, but for some reason or other it was not liked. The twelve-year-old molar below had come through, although the boy would not have attained the age of twelve for another three months."[3] (A detailed reproduction of this case with photographs and measurements is given in my book on the *Variations in the Form of the Jaws:* with special reference to their etiology and their relation to the occlusion of the dental arches (pp. 69 to 91).

Now let me refer to results which others have recorded, or told me of their successes and failures. In the *Dental Record* for *Sept. 1920* an extract from the *Lancet* was made on "The Problem of Dental Disease." It reads as follows:

> "The deplorable state of the nation's teeth is only too well known, and the health authorities are busily engaged in promoting schemes for treatment. At the recent meeting of the British Dental Association at Bournemouth, the chief interest centred round this perplexed problem of the dental needs of the public. Dr. R. A. Lyster, the medical officer for Hampshire pleaded in eloquent terms for further research into dental disease, and from his remarks as reported it would seem that the fundamental causes of dental disease are unknown and that it is therefore useless to lay down definite rules for prevention. This statement, if it gains currency, will tend to undermine belief in the excellent work that has been done on the etiology of dental disease and on which the present rules for prevention of dental diseases are based. These rules have already stood the test of time and produced excellent results, and have abundantly confirmed the correctness of the views held on causation . . . Mr. R. Lindsay in his public lecture admitted that the remedy was largely concerned with food, but considered that to ban any common foodstuff was outside the sphere of practical politics

in the question of the prevention of dental disease."

(This is recognized by the well-known rule that all meals especially the last one of the day should end with some detergent food such as an apple). Continuing his observations Dr. Lyster said:

> "But surely, if one is convinced of the cause, it is culpable negligence to evade the teaching of prevention simply because the obstacles to a radical change in diet appears too great.* The stoutest wall will give way before constant battering, and so with this question of food and dental caries. Dentists may be appointed to schools, to the army, to the navy, to maternity centres, but little headway will be made towards the banishment of dental disease unless the simple rules of prevention are inculcated. It is indeed a stigma to medicine that the most prevalent disease of the human race is the most easily preventable."[4]

Now let me refer to another example of comments on the excellent results which have followed the advice which I favor. It was published in a review[5] of my book on *Child Welfare* and the Teachings of Certain Dentists, School Medical Officers of Health and other Medical Men. On the whole the reviewer seemed to be favorably disposed towards my views but there was one paragraph which called for a reply or explanation. It reads as follows:—

> "It seems to us, absurd that, if dental caries is a preventable and easily controlled disease, the country should be put to the expense of the enormous sum it expends on dental treatment. It seems to us that the problem lies as follows:—'Our grandparents teeth did not decay and they took no trouble about them; our teeth (with certain few exceptions) do decay in spite of all sorts of prophylactic treatment. Wherein lies the difference and why do some escape? No satisfactory reply to this question has yet been given, so far as we know. But we do know that excellent results have been obtained by those who have followed out Dr. Sim Wallace's advice, though in certain cases no amount of care seems to obviate caries and in certain others his dietary rules are neglected with no ill results. Why?' "

In the following issue of the *Dental Record, (March 1920)* my reply to this question was published, it reads as follows:—

> "You very kindly refer to the fact that when my advice has been followed out excellent results have been obtained, but you refer to certain cases, where no amount of care, seems to obviate the disease and ask, 'Why?' Let me give you an example. I was told by the parents that my advice was being most strictly followed, yet I found decay between the temporary molars of a little child of about five. I could not politely say that my advice

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*In a recent article on Advice for Nurses in *New Health*, 1939, the recommendation is given to adopt the wholesome habit of eating half a raw apple, skin as well, after each of your three meals. Actually, the writer of this article in *New Health* thinks this is the finest toothbrush, and concludes his article by saying his children, now in their ninth year, have so far never been introduced to a toothbrush, only plain water and raw apple religiously eaten after each meal (p. 39).

was not being properly carried out, especially as the parents, (one of whom was a qualified dentist) were supporters of my views. Subsequently however, a friend who, by chance, both knew my views and those of the parents said to me, 'What a shame it is that ———should get so many sweets; she and her nurse never seem to be without them.' Let me give you another example of following out my advice. In a certain family the father did not know what was going on at lunch time until he unexpectedly appeared and found jam on the table. It then transpired that a rule had been established during the war that jam should be allowed when he was not at home. (Op. cit. p. 176).

"Many years ago Dr. W. D. Miller maintained that if a race of human beings or of animals were to make no use of their teeth for several generations, we should expect to find a gradual deterioration of the dental structure. It is, to say the least, highly probable that the soft quality of many of our foods, as compared to those of uncivilized races, conditions a soft, porous dental substance, as well as an imperfect development of the jawbone, and a concomittant crowded position of the teeth."[6]

I am glad to say I have been unable to find any evidence of this assumption in Dr. Miller's recent writings.

Similarly, the assumption that drinking water, which is deficient in lime salts, predispose the teeth to caries, has, I think, received its quietus from Rose, whose investigations, although apparently intended to support this theory, only seem to show that, if there is anything in the idea at all, it is practically a negligible quantity. Thus, in his recent investigation into "The Teeths of the Inhabitants of Delarne and Gothland," he admits and concludes that "it is the exceptionally hard bread eaten exclusively by the peasants in North Sweden that preserves the teeth of the Delarne people, and keeps them in such sound condition, whilst the Gothlanders ruin theirs by eating black bread, which is soft and sour, and which, furthermore, contains sugar."[7]

In like manner, Dr. Miller, believing in a qualitative difference in the teeth, expected to be able to elucidate experimentally the cause of the varying "susceptibilities" of different teeth,[8] but, as far as I can gather from his recent work, his investigations have given little or no satisfaction to his expectations, although possibly they show some teeth may decay more rapidly than others when once caries is commenced.

It is a noticeable and praiseworthy fact that the researches of those who set out to substantiate certain theories have, by the completeness of their own investigations, done great service in showing how unimportant these theories are in the explanation of "susceptibility" and "immunity" to dental caries.

The extinction of erroneous beliefs has the satisfactory result of concentrating attention on those that may contain the truth, and I believe it is impossible to arrive at a clear appreciation of the etiology of dental caries till we get rid of two other prevalent and erroneous assumptions.

The first that we must banish from our minds is nothing less than the gratuitous assumption of "susceptibility" and "immunity." When we see caries advancing rapidly in any mouth we are not justified in assuming the existence of "susceptibility." Before doing so we should be able to prove that the rapid advance of caries is not the result of some dietetic error, or some other perhaps unknown external factor. To say that the teeth are susceptible or immune in any particular case is to assume that we know every possible external condition which may have brought about the caries . . . Surely the persistent failures of those who have so laboriously searched should make us pause and ask first if there really is such a thing as this occult "susceptibility" and "immunity" to caries. The futility of this wild goose chase has only been excelled by the search for the cause of the prevalence of caries in an assumed "hereditary predisposition."

Then, again, there is the assumption that the diet of the several persons in any one family is essentially the same. They assume without investigation that children in the same family have similar dietetic habits, that they are brought up in the same way on the same diet, and that this is undisturbed either by natural or unnatural preferences in food, or by abnormalities in the visible structure and arrangement of the teeth. Do those who assume identity of diet take the trouble to investigate the habits, tastes, preferences, and dietetic vagaries of those in the same family who are "immune" and those who are "susceptible?" Suppose they are able to do so, suppose they are able to discover some of these little vagaries which seem to afflict more especially the modern child, do they calculate the relative fermentability of that portion of the food which does lodge when, for example, there is a variation in the time taken over a meal or in the thoroughness of mastication? Do they think it makes no difference if, for example, bread is eaten with, before, or after a glass of milk? Do they consider the time and arrangement of the meals? Do they know the effect of a relatively dry meal on the flow of saliva for the five minutes following the completion of the meal? Do they calculate whether acid foodstuffs increase the flow of saliva after the meal is finished, and, if they do, are they sure that their knowledge of the patient's diet and dietetic habits, and the self-cleansing processes which they set up in the mouth is sufficiently exact to tell whether the mouth will be physiologically clean three minutes or three years after the taking of the food?

A clinical investigation of a complex subject such as this is difficult and requires constant observation, analysis, verification, and cross-examination.

To get even simple statements of facts often presents difficulties. This may be illustrated by one or two cases from recent experience. A mother came with two children, aged eight and four years respectively. The child of eight had all her teeth free from caries, the younger child had four teeth with caries more or less advanced. I asked if they had both been brought up in exactly the same way. The answer was yes. I went into detail, and found that the child of eight had never been allowed to eat sugar or sweets, as it had given rise, according to her doctor, to a skin eruption; while the younger child was fond of, and ate liberally of, sugar and sweets. I asked the mother if she considered that the two children were fed in exactly the same way when one had sugar and the other had saccharine. Her reply was that she thought this was of no consequence, as she understood the theory that sugar was harmful to the teeth had been exploded long ago. It is not the tendency to lie, of course, which makes people say that the children in any particular family are brought up exactly alike when they are not; it is simply ignorance of what the differences are which, in the course of years, give rise to materially different results. In the case of sugar, some of us have at least suspicions about it, and we can direct our questions to some purpose. It is not easy, however, to arrive at the effect of some dietetic variation if we do not know what it is, or at least have no suspicion in our minds as to its possible effect upon the teeth.

Another difficulty, and curiously enough, a rather common one, is illustrated by the following: A patient came with a friend, and the friend entered into a discussion with regard to the cause of caries. She said she had perfect teeth, and so had her mother. I asked her with regard to her dietetic habits, and from what she told me came to the conclusion that in all human probability some of her teeth have decayed. I told her that my theory could not account for her case. The conversation became more jocular, and, in course of time, she broke out into rather hilarious laughter. Just at that time I observed a gold clasp encircling her upper second bicuspid on the left side.

There are other valuable observations on this subject to which I might well refer but for the sake of brevity shall restrict my remarks to the penetrating observations made in a communication by Dr. Lilian Lindsay, L.D.S., who is now, (1947) not only President of the British Dental Association but also unique in the recognition of her merit indicated by the letters, C.B.E., L.L.D., Edin., M.D.S., Durham, F.D.S., R.C.S., Eng., H.D.S., L.D.S., Edin. Her communication was entitled: "Can caries be Prevented on the Lines Laid Down by Dr. Sim Wallace? Evidence from actual experience."[9]

She commenced by saying:

> "Prevention of Dental Caries, like the philosopher's stone, the elixir of life, or Eldorado, has been sought by men of varying degrees of wisdom from the dawn of history, prevention rather than treatment was the method by which men believed that such disfigurement and disablement as the loss of teeth, inflicted upon him could be avoided. Very little research will prove this to be true: . . . Meditation on this subject of prevention led me to the decision, that the only way to arrive at a satisfactory and reliable conclusion as to the value of any form of prevention was to have access, if possible, to concrete examples of actual cases in practice."[10]

Much care was taken by Mrs. Lindsay in estimating the value of the evidence and the reliability of the information which she was able to get either in dental literature, or records of actual cases. The communication, though necessarily long, was most interesting and important, but I shall only refer to two of her recorded cases and a commentary I culled from my book on *The Cause and Prevention of Dental Caries* (1906) which was briefly referred to already in this communication. It indicates how both Dr. Lilian Lindsay and I arrived, quite independently, at what was essentially the same conclusions, notwithstanding the totally different nature of the cases recorded. The paragraph in Dr. Lindsay's paper to which I refer reads as follows:—

> "Two of the cases in which the guardian of the children expressed great concern over two girls between the ages of six and twelve, who had been under the Sim Wallace regime, which was strictly enforced. Four of the sixes in one child and two in the other showed caries before the age of twelve, but on a more attentive inspection these cavities turned out to be pin points, and a doubt may creep into the minds of those who have had much experience of patients who declare solemnly that they have been so strict with their enforcement of the rules of diet, for, as one of my correspondents put it politely, 'patients are far from frank', when he instanced the case of a family who were frequent in their demands for his services, denying any excessive consumption of sweetstuff. But, unfortunately, for their veracity, friends, also patients of the dentist, commented in casual conversation that the consumption of sweets in the aforesaid family was almost continuous. Patients do not always wander from the truth consciously, but are mistaken as to what you consider to be strict adherance to the rules of diet you lay down to them. Only recently I was visiting a family where the youngest boy, aged four, had all his temporary molars filled. Of course, I asked for the reason, and on inquiry, I was told that supper had been abandoned as a last meal as it did not agree with the child, his last meal was at 4:30, and that was the usual nursery tea. Later I was invited to say good-night to the children after they were in bed. Beside the bed was a tray with a glass of milk and a plate of biscuits. I pointed this out to the nurse, who said: 'Milk is so good for him, and of course I always brush his teeth afterwards.' Now, the children had their own bathroom, and there was no sign of any washing apparatus in the bedroom, so I came

to my own conclusions on the matter of decay in the boy's teeth. The parents thought that a glass of milk and biscuits did not constitute a meal, and they assured me that they had every confidence in the nurse, as she understood children so thoroughly."[11]

The foregoing careful, telling observations together with her extraordinary knowledge of dental literature and science may give some little indication why Lilian Lindsay has rightly become the most honored woman in the history of dentistry.

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# Chapter XV

## STATISTICAL RESULTS, PRE-WAR AND POST-WAR (1914-1920)

Turning now to statistics recorded with regard to dental caries and the results of changes in diet during the first World War, let me reiterate that before taking up the study of dentistry I had been taught, or had learned, that acquired characters were not inherited. There were of course conflicting views on the subject at that time, (1890) but with regard to mutilations, all scientists agreed that they were not inherited. This being so it seemed to me astounding that the theory of hereditary predisposition to caries should have been so unquestionably accepted. Does not acid on the skin *mutilate* it; and what special difference is there in caries of the enamel? It is primarily simply a mutilation caused by the action of acid, and there is no physiological reaction to it on the part of the enamel. Whether the enamel be thick or thin, hard or soft, sclerotic or malacotic, does not really matter, for, in any case, acid mutilates it.

Here we may refer to some work done in England, and to note the share she took in directing the course of useful beliefs with regard to the etiology of dental caries.

A dentist named William Robertson published a book in 1839, and wrote the following sentence:

> "The only cause capable of explaining the partial operation and the particular situations of decay is the corrosive or chemical action of the solid particles of food which have been retained and undergone a process of putrefaction or fermentation in the several parts of the teeth best adapted for their reception."

Unfortunately, towards the latter end of the nineteenth century his work appears to have been all but completely forgotten. However, my friend, the late Mr. George Thomson, drew my attention to Robertson's work and I lost little time in bringing the sentence quoted to the notice of the profession. I cannot help thinking that it was erroneous beliefs with regard to hereditary degeneracy and immunity to caries that led dentists to disregard his work. However that may be, as I have indicated, the firm conviction that acquired characters were not inherited compelled me to discard the prevalent assumption that dental caries was hereditary, and led me to observe, as Robertson had done, that caries invariably was most likely to start on such parts of the enamel, as were liable to retain or lodge certain kinds of foods. Of course, when Roberston wrote, nothing was known about bacteria in fermentation. Pasteur had not even commenced to write, the role of bacteria and carbohydrates in the production of acid was unknown, and the chemico-parasitical theory of caries was not established. Further, the belief in the inheritance of acquired characters had not been overthrown, nor was it seen that the idea of immunity to caries in the enamel was an untenable belief.* The data, therefore, on which I was able to start my investigation with regard to the cause of caries were far more satisfactory than in the time of William Robertson and led me to a re-investigation of diet, not from the nutritive point of view as medical men had done, but from the point of view of the frequency of caries.

My earliest work was in the nature of a simple attempt to find the relative lodgeability of fermentable carbohydrates. For as it appeared to me, the essential question with regard to causation was whether fermentable carbohydrates lodged unduly in the crevices and retention areas so as to furnish the pabulum necessary for the proliferation and activity of the acid-forming bacteria. I made many observations in my own mouth with regard to different articles of diet, and frequently was able to get much useful information about the dietetic habits of my patients. I took a similar interest in the nonfermentable carbohydrate cellulose and various other articles of diet which were known not to give rise to acid fermentation. It soon became evident that there were various accessory food factors which, though in no way directly conducive to nutrition, were of great importance from the point of view of dental and oral hygiene. Let me dwell briefly on these accessory food factors to which I refer. Cellulose generally occurs in natural food in a somewhat fibrous form, and the mastication of this tends to clean certain surfaces of the teeth. We see that this is conducive to oral hygiene, but it is not appreciably nourishing to man. It is not necessary to refer further to this, since the idea is fairly accepted, and Dr. Percy Howe has generously corroborated my views with regard to cellulose and the roughage in vegetable foods generally.[1] Next, we may have food of a certain physical consistency, which, too, necessitates mastication. But the physical consistency of the food, though it may be detergent or cleansing with regard to the teeth, is not nutritious.

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*This subject is more fully dealt with in my book on Oral Hygiene, 1929, pp. 74-77.

Again, I drew attention to the effect of such acids, as may occur in natural foods, and explain why these acids were not only not harmful, but actually beneficial from the point of view of oral and dental hygiene, and you may remember that a number of years afterwards Dr. A. P. Lotrop and Professor W. E. Gies of New York amply and likewise generously corroborated my views. I also referred to "bitter, pungent and stimulating principles" in the food, because, like acids, they caused a copious flow of saliva, which I regarded as the natural mouth wash that should be stimulated, while "soft, alkaline, insipid," milk-soaked diets, such as were generally given to children, were condemned. Since referring to these factors more than forty years ago, the value of acids in the food has been taken up by members of the dental profession, by some too enthusiastically; indeed attempts seem to have been made to overshadow other important food factors by a much too enthusiastic and exclusive insistence of the value of acids. Second hand versions of new ideas are often misleading and unsatisfactory, especially when the real source of the ideas is not divulged, and Professor Gies was well justified in drawing attention to the fact that recognitions of priority "help to define the limits of knowledge, to show the sources and to indicate the reliability of information, and through the penalties that follow discovered plagiarism and other forms of misappropriation, to prevent the demoralization of literature, as well as the confusion of the records of Science."[3]

I am also inclined to think that the vitamin craze looks only like a wild magnification of the idea of the "stimulating principles" referred to.

Associated throughout with the study of these accessory food factors, there were corresponding inquiries into the physiological processes in the mouth which those factors set up. One of the first to attract attention was the physiology of mastication. I tried to show that the description of the process as given by physiologists was erroneous and misleading. It represented mastication as a process for the making of a bolus to be lubricated with saliva and mucus in order to faciliate the lump thus formed being swallowed. Whereas my contention was that anything in the nature of a bolus was disintegrated during mastication and swallowed in liquid or semiliquid form. If my view be true—and it is so regarded by dentists in England—then it seems to follow that the intimate mixture of the disintegrated and semiliquid food that reached the stomach would allow the gastric juice to permeate the more readily into its contents, because of the precipitation and curdling of mucus by acid. This is the antithesis of what some physiologists at the present day suggest. With regard to saliva, the idea gradually dawned on me that its function was not primarily to digest starch, but rather to flush the mouth and keep the teeth and gums in a healthy condition. Two principles of importance originated from these conceptions. The first was that the physical consistency of food for young children with a complete set of temporary teeth ought, in general, to be such as would require efficient mastication and stimulate the glands of oral hygiene. The second was that in the event of non-fibrous food being eaten, of a physical consistency making it liable to lodge about the crevices of the teeth, this should be followed by foods of a detergent nature.

It is, of course, impossible in a short address to recapitulate all the points brought forward, together with reasons for insisting on the necessity of recognizing them, nor can I attempt to reproduce the evidence which helped me to formulate guiding principles of dietetics, and more especially the principles of dietetics for children. I would, however, like to refer to some incidents which have happened in England. Let us go back to 1900, for we have recently been informed by the *British Dental Journal* that in that year "one of the most controversial and epoch-making works in modern preventive dentistry appeared."[4] At that time the chemico-parasitical theory had become thoroughly established and the responsibility for what took place in the teeth was so directly traceable to the micro-organisms in the mouth that the dental profession was practically unanimous in urging preventive measures to be taken in such a way that these micro-organisms should be filled with antiseptics and cleared away with the toothbrush. It was supposed that carbohydrates in the diet necessarily favored the acid-forming bacteria which destroyed the teeth, but, of course, it was obvious that carbohydrates could not be excluded from the dietary, more especially such carbohydrates as bread and potatoes, which Miller considered the best able to cause rapid acid fermentation. In fact, at that time preventive dentistry amounted to little more than toothbrush drill and the use of antiseptics, together with a few variations in methods and specifics used. I believe that in the schools in England these procedures were quite a failure from the point of view of the prevention of caries. It was even pointed out in high scientific circles that in the upper-class schools in which the toothbrush was used the teeth were more subject to caries than where it was not—that is to say, in the poorer class schools; while dentists were repeatedly confronted with the failure of those who claimed to follow the preventive methods most carefully and they lapsed into the habit of blaming the continued increase of the disease on hereditary and constitutional causes.

To me, these methods of prevention seemed very ineffectual. My early training had been in science, and more especially in biology, and so, naturally, my first book, to which we have just referred, written in 1900, was rather a defense of the principles of biology I had learned, for to me it was evident that the principles and practice of preventive dentistry, as then taught, were unwittingly based on the assumption that the principles of biology were erroneous.

Though the textbooks which appeared before 1909 contained little more than such remarks as would indicate that my views were of little importance, as time went on they generally became more recognized. Sir Frank Colyer introduced them in his well-known textbook, and Sir N. G. Bennett asked me to write the section on the etiology of Dental Caries in his. In fact my views became "official" among dentists in England, and as the cause of prevalence of dental caries was recognized, so too was the fact that it was a preventable disease. In addition to this, a few physicians who wrote books on the care of children took notice of some of the new dietetic principles, and two or three of these have had a considerable effect, for they were and still are widely read by medical men, and as some books on the care and feeding of children became well-recognized guides for mothers, direct instruction was brought home to those who had children to bring up. Some doctors were indeed perhaps too enthusiastic and sweeping or "previous" in their pronouncements.

Thus in a leading article on "Diet in Childhood" in the *Universal Medical Record,* 1912, it was said that "in the last few years the diet of the children has been entirely reconsidered. Much of the traditional feeding has been rejected, and in its place a carefully-thought-out dietary, based on scientific principles, has been established," and moreover, generously added that "it is to the dental profession that in the main we owe these advances." So, too, a few medical officers of health, whose duty it was to instruct the public on the preventon of disease, became interested in the subject, and some of them seemed to prefer our views with regard to diet for children to the views of children's specialists. Notable among these was Dr. James Wheatley, Medical Officer of Health for Shropshire. After studying the subject thoroughly for himself, he brought it forcibly before the medical profession in his branch; he lectured to the school teachers, nurses, and health workers, and prepared leaflets for the instruction of the parents in his county. The result of his campaign was so striking that a few figures may here be given.

From the following table you will readily notice a decrease in dental caries as a result of the practical application of the dietary reforms advocated. It is a comparison of the inspection of 37,527 school children in the pre-war years (1910-1914), with the inspection of 10,503 school children in 1919 and the first three months of 1920.

| Year | Age 5 | | Age 12-13 | |
|---|---|---|---|---|
| | Number of Carious Teeth per Child | Percentage Free from Caries | Number of Carious Teeth per Child | Percentage Free from Caries |
| 1910-1914............. | 6.4 | 5.0 | 4.6 | 2.9 |
| 1919 (last three months) | 2.1 | 42.0 | 2.1 | 26.0 |
| 1920 (first three months) | 1.9 | 48.0 | 2.1 | 28.3 |

### FOOD IN WARTIME

The restrictions and modifications of food during the first World War were—

*Sugar*—Price rose from 2½d. in July, 1914, on the outbreak of war, to 6d. per lb. Since then it has varied from 7d. to 8d. per lb., and recently 10½d. Manufacturers were cut down to 50 per cent for confectionery, sweets, and jam. Amount of sugar consumed for all purposes before the war was 98 lbs. per head per annum; through the war consumption has been halved.

*Bread*—Offal was added to the flour. Pre-war extraction of grain, about 68 per cent, rose to 80 per cent in 1917, and continued at about this figure, or rather less, to present time. Sale of new bread prohibited; crusts eaten, not thrown away.

*Milk*—Rapid rise in price and diminished consumption.

It is difficult or impossible to apportion the effect on the teeth of these various alterations of food, but it seems likely that the wholesale cutting down of sugar and the almost total elimination of "sweets" was the most powerful factor.[5]

Dr. Wheatley recognized and admitted that these results were to some extent due to war conditions—for example, a distinctly curtailed amount of sugar, sweets, and milk. But that it was largely due to the campaign of instruction which he inaugurated in his county is made evident by the fact that other counties did not show nearly such good results. Roughly, altogether, I think it may be calculated that there has been at the very least a 20 per cent reduction in the amount of caries among school children when we compare the pre-war and post-war periods. This means that in England there has been a reduction in the number of carious teeth *in school children alone* of considerable more than 10,000,000, while among children of pre-school age there has been a more pronounced reduction. This is a conservative estimate, and it would probably be within the mark to say that there was a decrease of 20,000,000 carious teeth among children of pre-school and school age.

The wisdom in the new principles in the feeding of children and the excellent results already obtained probably accounted for the recent action of the Society of Medical Officers of Health in electing a committee to draw up a leaflet for the guidance of parents. In it you will observe that the older insipid pap-feeding principles of children's specialists have been discarded, and rational principles based largely on the teaching of dentists whose special concern was the physiology of oral hygiene have been adopted.

## PREVENTION OF DECAY OF TEETH*

### (Leaflet for the Use of Parents)

Simple and unpretentious though this leaflet may be, we dentists have, I believe, reason to be proud of it, for it is evident that the dietetic principles now authorized by the Society of Medical Officers of Health of England resulted from a recognition of our work. Nevertheless, it can hardly be said that we have as yet by any means reached our objective. As already indicated, it is probably true to say that through the diffusion of the knowledge of correct principles of dietetics the amount of caries in school children in England has already been reduced by more than 20 per cent. But if the community is to reap the full benefit, it is of special importance that all teachers and leaders of thought should become acquainted with the new knowledge. So far it must be admitted that physiologists and the majority of medical men do not even recognize that there is such a thing as the physiology of oral hygiene. Nor do they know that the primary function of the saliva has been discovered, and their knowledge of the physiological process of mastication is so limited that they still imagine a bolus is formed in the mouth to be lubricated with saliva and mucus, to be slipped down into the stomach as such.

It is, then, for us dentists to teach them by physiology of oral hygiene, and show them the necessity of recognizing the value of *all* such accessory food factors as are conducive to this end. The physical consistency of the food, fibrillar matter, more especially cellulose, food acids, aromatic and pungent flavors and stimulating principles, must *all* be taken into account. It will not do to confine attention to such stimulating principles as vitamins alone. Fortunately, the conceptions resulting from the study of oral hygiene have led to similar beneficient ideas with regard to alimentary hygiene; and the benefit derived from correct teaching does not appear to be limited to the decrease of dental caries, for not only has this disease decreased, but the general health of the children has also improved. Thus may we hope that dietetic experts, physiologists, and medical men generally may soon join us in promoting what promises to be the most notable triumph of preventive medicine.

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*This leaflet has already been published in Dental Items of Interest, Oct. 1930, p. 780. Sold singly or by the thousand, by the Peoples League of Health

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# Chapter XVI

## INFERENCES FROM EXPERIMENTS ON ANIMALS

Notwithstanding the practically unqualified recognition of the truth of the chemico-parasitical nature of dental caries which was elaborated by William Robertson, Magitot, Miles and Underwood, W. D. Miller, G. V. Black, and other dentists of outstanding merit, together with the Newer Knowledge of the physiology of oral hygiene as evidenced in the teachings of the most eminent authorities in Britain since 1909,* the Medical Research Committee issued a Report on the Present State of Knowledge Concerning Accessory Food Factors (Vitamins) wherein there is a Chapter (VI) on Rickets as a Deficiency Disease. Toward the end of the chapter it is stated that,

> "although the experimental work here summarized deals only with young animals, it is certain that the necessity of having abundant antirachitic factor in the diet is also of importance at a later stage. Recently May Mellanby has demonstrated the effect of diets deficient in an accessory factor, possibly fat soluble A, on the calcification of puppies teeth."[1]. . . .

Apparently she also thought that, "the adequate spacing of the teeth in puppies is dependent on an abundance of some such factor."[2] The chapter from which the foregoing quotations were taken concludes with an illustration of the teeth in the lower jaws of three retriever puppies which it was claimed showed (1) "The good effect of butter on the enamel." And (2) "the fastest growing puppy has the worst teeth." The foregoing introduced what we may call the pharmacological theory of the cause and prevention of dental caries and the irregularities of the teeth.

In the report of the Medical Research Committee a reference was made to a paper by May Mellanby in the *Lancet*. (Dec. 7th, 1918). Before this time little or no attention had been paid to vitamins in relation to the growth of the jaws, or the prevalence of dental caries in children, nor was the now generally accepted theory of the cause of caries referred to in the Medical Research Committee's Report, though the truth of the chemico-parasitical nature of the disease and its causation had been elucidated and fully supported by distinguished dentists with medical qualifications in this country during the first two decades of the present century. It is significant also, that The Royal College of Surgeons of England should on the 12th of May 1921 have presented to *me* the John Tomes Prize for my work on the Prevention of Dental Caries, that is to say, about two years after the publication of the Medical Committee's Report. Indeed, as far as I know, neither I, nor anyone else, with dental qualifications who have studied and written on the subject, have ever maintained that there was any necessity for having an "abundant" antirachitic factor in the diet, or "demonstrated" the effect of diets deficient in an accessory factor, possibly fat soluble A, on the calcification of puppies teeth.

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*e.g. Sir Frank Colyer, J. H. Gibbs, F.R.C.S. Ed., Sir Harry Baldwin and Sir Norman Bennett.

I need hardly say that some medical men who have occupied eminent positions in the public services and paid special attention to the subject during the first two decades have endorsed the views of the distinguished members of the dental profession who elucidated the natural method of preventing the diseases and irregularities of the teeth, together with the excellent results derived therefrom. Among eminent Medical Officers of Health I need only mention the names of the late Dr. James Wheatley whose statistical investigations indicated most gratifying results and to Sir George Newman's reports which showed his great appreciation of the views of the dental profession formulated during the first two decades of the present century. Notwithstanding all this and much more that could be seen from statistics on the prevalence of dental *caries in human beings* the lure of the catchword "vitamine" was dragged in, though it had little or no significance in explaining why all animals except men, women and children, were practically free from dental caries, irregularities of the teeth and septic oral conditions.

I have already referred to the statistical research of Dr. James Wheatley with regard to the incidence of caries before and after the First World War. Here I would refer to the views commended by Sir George Newman, Chief Medical Officer of the Board of Education, in his Annual Report for 1916. Therein he says:

> "There are various physiological means by which the teeth are kept in good condition. There is, for instance (a) the saliva which performs functions of a (1) cleansing character, and which also (2) controls fermentation and (3) aids in the protection of the teeth; (b) sufficient exercise of mastication, which furnishes a self-cleansing process for the mouth; (c) a suitable dietary containing detergent forms of food."

As already said Dr. Wheatley recognized that the great reduction in the prevalence of caries among children commencing shortly after the First World War, was to a great extent due to the very distinctly curtailed amount of sugar and sweets, together with an increased amount of foods which induce mastication and stimulate the physiological self-cleansing processes associated therewith.

The importance of the subject, as recognized by Sir Frank Colyer, Mr. J. H. Gibbs, F.R.C.S. and L.D.S. Edin., Sir Harry Baldwin, Sir Norman Bennett, Sir George Newman, Dr. Harry Campbell and many others, seems to have led the Medical Research Committee to induce May (now Lady) Mellanby to take up the subject on the lines adopted by Magendie who was perhaps the first to make experiments on dogs which demonstrated that certain deficiencies in the nutritional qualities of food gradually, but fairly quickly led to disastrous results. To make my meaning clear let me quote from a chapter on the Discovery of Vitamins in a somewhat recently published book by W. R. Aykroyd, M.D., (Late Beit Memorial Research member of the Health Section, League of Nations). Therein he says:

> "The real scientific history of the vitamines dates from the time when eighteenth century mariners proved that the great plague of seafaring men, scurvy, could be prevented and cured by fresh green vegetables and fruit.
>
> "In the laboratory, there were no developments until thirty years ago. Magendie, however, describes one experiment, performed about 1820, which seems to anticipate many experiments of modern times. It was reported in the London *Lancet* of March 11th, 1826, as follows: 1. A dog fed on fine white bread and water, both at discretion, does not live beyond the fiftieth day. 2. A dog, fed on the coarse bread of the military, lives and keeps his health."[3]

This might have led to the idea that

> "it need only be remarked that one of the differences between bread made from unmilled wheat, and bread made from refined wheat flour is that the former contains a good deal of cell-membrane, derived from the germ and bran of the wheat grain."[4]

Further on (p. 72) Aykroyd says

> "It seems an irrational procedure first to remove the germ and pericarp from rice, and later, when the consumption of improved rice leads to beriberi, to restore them to the diet to save the patient's life."

In this connection he refers next to the "Brown Bread controversy" which

> "raged before vitamine B was heard of, because whole meal and refined wheat flour differ in their contents of other nutritional factors apart from

> vitamines, but the discovery of the superiority of brown bread over white in vitamine B content has lent fresh life to the discussion. . . . There is really little reason to believe that the average English or American dietary, whether it includes wholemeal bread or not, contains insufficient vitamine $B_1$ for health . . . Fortunes have been made in recent years out of the sale of 'vitamine B' preparations in tins with attractive labels; so in the past were fortunes made out of elixirs of life and infallible plague preventive."

While Dr. Aykroyd says that

> "much nonsense has recently been talked about the deficiency of vitamine B in our modern city dietary"

he omits to note the same fact with regard to all the other vitamins. He might well remember the words already quoted from Magendie:

> "La diversite et la multiplicite des aliments est une regle d'hygiene tres important."[5]

To get nearer to inferences made in relatively recent years with regard to diet and the structure of the teeth in dogs we may here refer to "An Experimental Study of the Influence of Diet on Teeth Formation."[7] In the summary of results made by M. Mellanby, she concludes by saying:

> "The evidence makes it clear that this is an instance of diet affecting the teeth from the inside and is independent of bacterial sepsis and other oral conditions associated with food."

No doubt this is all quite interesting and may well be associated with her next research which

> "was started under the auspices of the Medical Research Committee with the idea that it might be possible by animal experiments to discover (1) the factors involved in the development of sound teeth and in the growth of the jaws in relation to the size and arrangement of the teeth. (2) The conditions which affect the immunity of erupted teeth to caries and other diseases."[8]

Continuing she said that all she

> "hoped to do was to contribute some facts which would help in elucidating these important and pressing problems."

The first fact to which she alludes is that

> "it can be stated as a fact that puppies fed on a diet which produces sound teeth and well-formed jaws are just those which are the most resistant to the diseases common to this type of animal."[9] . . . .

Other facts which she gives and all students of the subject have known many years, are that:

"The teeth of neolithic man were excellent. The teeth of the Esquimaux in his own country are very good. The teeth of civilized man are dreadful."[10]

She then asks the question: "Is there a simple explanation of these facts? Is there an explanation that can be acted upon?" Of course there is, and it has been taught not only by me, but also by learned exponents in this and other countries and embodied in the most authoritative textbook on Dental Surgery in this country a goodly number of years before Lady Mellanby took up the subject. The diminished consumption of sugar and sweets in the First World War surely showed excellent results. Nevertheless, Mellanby in a paper delivered in November 1919 said,

"The results to be described in this paper were obtained by experimenting on domestic dogs, and I am quite aware that such work is open to criticism, especially as the results have not yet been extended to human beings. The critic can always say, 'this applies to puppies but children are quite different.' As a matter of fact the diet and the general metabolism of the domestic dog is as near that of the human being as any other living thing. Like man the dog is omnivorous."[11]

"No doubt a dog may eat grass at times and swallow lumps of chocolate, but it greatly prefers to eat meat and gnaw bones. Zoologists classify it as *carnivorous* and its dentition is certainly of the carnivorous type". . . Continuing Mellanby says,

"I certainly realize that before the results can be definitely applied to man, the work must be repeated on him and he must remain the final test object."[12]. . . .

Further on she goes on to tell us something about vitamins, and says it will be well to say something about these substances.

"Only very small quantities are necessary in the diet, amounts quite out of proportion to their importance, hence the failure till recently to realize their presence. . . . Let it be stated at once that there is at present no knowledge concerning their chemical nature.

"The name vitamin was given to these bodies because Funk claimed to have isolated one member of the group and found that it was an amine. Although those results have since been shown to be incorrect, yet the name has struck the imagination of the public and it is certainly more concise than the term 'Accessory Food Factor' used by Professor Gowland Hopkins, who was the first to appreciate fully the great importance of these substances as the result of his pioneer work."[12]

Here it may be mentioned that although the word vitamin was based on an incorrect assumption yet it struck the imagination of Sir Edward Mellanby and his followers. Nevertheless M. Mellanby tells us Prof. Gowland Hopkin's term was "more consistent with fact."

Many edible substances have a physical consistency which stimulate mastication. Many vegetable foods are partly composed of cellulose which is innutritious and cannot be synthesized by animals, yet as has been claimed by Prof. Percy R. Howe blotting paper which is composed of cellulose is quite effective in preventing and curing diseases of the alimentary canal. Similarly for two or three centuries, it was known that some fresh vegetables and organic acids synthesized by plants prevented and cured scurvy. These physical and chemical qualities might quite reasonably be called accessory food factors, just as the physical and chemical properties of foods which stimulate mastication, the saliva, and other glands of alimentary hygiene may help to prevent scurvy and dental caries, pyorrhea, etc. Some of us do not want words simply because they are "concise" or have "struck the imagination of the public." Facts are wanted, such as the results of the application of dietetic regimes voluntarily or under the stress of circumstances which were imposed upon us during the first and second World Wars, e.g. the greatly curtailed import of sugar together with the rationing of sugar, sweets, jam, etc.

An analysis of pre-war and post-war regimes gave us statistics of great importance with regard to the cause of the prevalence of dental caries. Such statistics were deprecated by Aykroyd and the animal experimental methods followed with approval. Let me indicate here something more about animal experiments nearly thirty years before Aykroyd's second edition on "*Vitamins*" was published. In a leading article dealing with Physical Degeneration in Relation to the Teeth it was observed that my:

> "deliberate opinion that food demanding thorough mastication in the mouth is not only best for the teeth, but also for the stomach and intestines, and that the early decay of teeth and the sluggish action of the alimentary canal, which is evidenced by indigestion and constipation, are the direct outcome of the eating refined, soft food." . . . the article continues saying that I am prepared to attribute this unnatural tendency not only to dental caries, but also diseases such as appendicitis, rickets, neurasthenia, adenoids, and anemia. . . . It is a well-known fact that the physiologically perfect products of the laboratory combined in theoretically perfect quantities frequently fail to nourish those to whom they are administered whilst natural foods that contain much that appears unnecessary and harmful, agree well."*

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*Quoted from a leading article in *The Medical Press*, 1905, dealing with a paper I contributed at the Annual Meeting of the B.D.A. Aberdeen 1904 and reproduced in my book on Diet and Diseases (1905) in Chapter VII p. 71.

In the scientific experiments approved of so highly by Aykroyd the nutritive material was purified no doubt beyond suspicion but no reference was made to the benefit of any bulk, ballast or innutritious matter or the physical nature of the food which is required to stimulate mastication and the rhythmic actions of the alimentary tract.

Sir Henry Thompson in 1899 who was probably the highest authority on Food and Feeding when referring to bread said:

> "No portion of the husk of the grain should be removed from the wheat when ground, whether coarsely or finely, into meal. That a partial removal is systematically advocated by some as an improvement, is one of the numerous illustrations of the modern and almost universal craze which just now exists among food purveyors of almost every description, for eliminating all inert or innutritious matter from the food we eat."[13]

For the elucidation of the cause of caries it may well be admitted that the dog does give evidence that the food theory is correct. While as we shall see later the theory that diet affects the teeth from the inside is erroneous as far as dental caries is concerned. Let me quote a few sentences from a textbook which Dr. Aykroyd has apparently overlooked even though it was written by one of the highest authorities on the diseases of the teeth. I refer to the work of W. D. Miller, D.D.S., M.D., entitled *The Micro-organisms of the Human Mouth.* Therein with regard to dental caries, he writes:

> "Bland Sutton, who has occupied himself with this study for many years, found only a small number of decayed teeth in carnivora, and these almost invariably in animals living in captivity for some length of time." (p. 200). . . .

According to Miller's observations,

> "every considerable collection of dogs skulls will be found to contain one or more decayed teeth, nor is decay of very rare occurrence in horses and apes. In two hundred and ninety-five dogs skulls, mostly of the bull and lap-dogs, I found eighteen cases of decay; in six, two teeth were decayed; in each of the remaining twelve, one" . . . .

In all these cases it was invariably the first upper molar that was decayed, which is explained by the fact that this tooth possesses deep retaining points for food particles on the grinding surface.[14]

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# Chapter XVII

## VITAMINS, DENTAL CARIES AND SUGAR

Since the publication of the Report on the Present State of Knowledge concerning Accessory Food Factors (Vitamins), other consderations have arisen. Firstly we may refer to sugar.

There have been conflicting views on sugar as a cause of dental caries, but it should be noted that the physical and chemical characteristics of different kinds of sugar are more or less markedly different. Thus sucrose or cane sugar has the chemical formula $C_{12}H_{22}O_{11}$, and is decidedly sweet. On the other hand "sugar of milk, lactose, has the chemical ($C_{12}H_{22}O_{11} + H_{20}$), and occurs "as a gritty powder of moderately sweetish taste." While glucose is defined (in the U.S.P.) as a thick syrupy liquid obtained by the incomplete hydrolysis of starch, composed mainly of dextrose and various dextrines."[1] Little notice was taken of the dissimilarities in the physical and chemical differences of these sugars with regard to dental caries or oral and alimentary hygiene in the first two decades of the present century. However, about the end of 1918 much interest began to be taken with regard to vitamins in the causation and prevention of the diseases of the teeth. One of the most important books on this subject was published in 1935 entitled—*Studies in the Aetiology of Dental Caries* written by G. Graham Macphee, M.A., M.D., Ch.B., L.D.S. In this book Dr. Macphee, while reviewing the state of our knowledge up to this date, lead me to doubt the "great value" of certain experiments on dogs with regard to vitamin D in relation to hypoplasia and the etiology of dental caries. It was recognized moreover by Dr. Macphee that the researches were carried out with "painstaking thoroughness" and at "enormous expense." But he concludes the paragraph from which the foregoing extracts were made. "It is now seen, however, that vitamin D is only one factor and can no longer be held as a complete explanation of caries as was at first hoped" . . . . "In short, vitamin D, which occurs naturally in certain fats, but most abundantly in cod-liver oil and some other fish oils, is an essential constituent of human diet. Its absence during the period of growth is followed by rickets and hypoplastic teeth. Although the evidence is conflicting, such hypoplastic teeth are probably more susceptible to dental caries than strong well-formed teeth."[2] On page 65 of Macphee's book it was stated:

"Hitherto the experimental evidence offered by Mellanby and her co-workers was accepted without question, but in 1932 McCulloch reviewed the most recent investigation at that time, and showed that not only were the conclusions drawn from the experiments unjustified, but the experiments themselves were fallacious." After some further severe criticism by McCulloch (*British Medical Journal* 1932, ii, 75), Macphee says:

"Although McCulloch's criticisms appeared well over two years ago, no satisfactory reply appears to have been published by Mrs. Mellanby or her co-workers." (Macphee. op. cit. p. 66).

Continuing Macphee says:

"The production of vitamin D by the action of ultra-violet radiation on the skin or the ergosterol contained in it would lead us to suppose that children living in a sunny country should have better teeth than British children, if vitamin D really is as important in relation to dental caries as its advocates claim. In England, according to Shaw (1932), the total annual insolation is less than half that at Johannesburg, where the actinic rays of the sun are more powerful than in England. Therefore he considered that the actinic rays of the sun were ten times as effective in Johannesburg as in England (actually four or five times), and dental caries ought to be very rare. Yet he found just as great an incidence of dental caries in 600 school children in Johannesburg as in England, though in South Africa rickets is almost unknown. Moreover, he stated that native children wore no clothes at all till 12 years of age, and so got all the possible actinic rays of the sun, with their vitamin D-producing effects, yet 74.1 per cent have dental caries. This correlation between vitamin D, calcification and ultra-violet rays was mentioned by Talbot (1934).

"That the claims of vitamin D to be a preventive agent against dental caries are overstated has long been felt. Experimental evidence, however well presented, may be convincing to those unacquainted with the pitfalls of such methods, but when an experienced research worker, like McCulloch, exposes the fallacies of one set of experiments, doubt is thrown on all the others. Even if the methods were unimpeachable, it does not necessarily, or even probably follow that effects produced in rats and puppies must result in human individuals.

"In my (i.e. Dr. Macphee's) experience, one patient seems to contradict the whole vitamin D theory. This patient, a boy aged fourteen, in 1933, whose father is a scientist, has been brought up for the last ten years on cod-liver oil in abundance, milk, orange juice, and all those things which ought to produce good teeth, including, more recently, synthetic vitamin D. While his temporary teeth were moderately good, his permanent dentition shows rampant caries of the rapid type. Although it is easy to say that this single case is an exceptional one, it is difficult to explain satisfactorily to the intelligent parent why the vitamin D therapy and other measures have failed so completely.

"The fact that children of better class parents, who get more expensive food which is rich in vitamin D, have worse teeth than poor children who live on cheaper food, less rich and often deficient in vitamin D, is an argument against the importance of vitamin D as a factor in the etiology of dental caries.

"Some of the criticisms directed against vitamin D may appear to have been given here at too great length, but this has been done in the hope of counteracting the overenthusiasm of some of its advocates." (Macphee Op. cit. p. 68).

Bearing in mind the chemical and physical nature of the different sugars noted in the first part of this chapter need we be surprised to learn that the addition of a few spoonfuls of milk containing "a gritty powder of moderately sweetish taste" would transform a "purified diet" devoid of these and other stimulating factors into a sufficiently wholesome diet to maintain life and health; it has been frequently contended from 1900 that fibrillar cellulose stimulates mastication as likewise do other innutritious ingredients such as are found in the cortex of grain. What indeed could we expect to be more beneficient than suitable innutritious substances to stimulate mastication and the muscles whose function it is to cause peristalsis from one end of the alimentary canal to the other not to speak of the various mucous and other glands which facilitate the mechanical as well as the vital activity of the phagocytes?

Many years ago while writing on "Oral Bacteria and Acquired Immunity to Disease" I recall the fact that

"The tissues of the mouth are particularly well able to resist the invasion of micro-organisms, and the stomach has the power to digest and kill the great majority of the bacteria which enter it. . . . Disease only supervenes when the invading parasites overcome the natural defensive arrangements of the body."[3]

I further quoted Sir Watson Cheyne who (in The Wightmen Lecture, 1908) said

"The first line of defence of the body resides in all probability, in the epithelial tissues which oppose the entrance of infective agents into the body."

Now let me refer to what might be called Nature's unbiased exposition of the truth with regard to cane sugar and dental caries. My attention was drawn to the subject by a short notice in a daily newspaper under the heading—No sweets: Good Teeth.

Skye Island Record for Scotland. It read as follows:

"The school children of the lonely Gaelic-speaking township of Aird-of-

> Sleat, in the extreme south of the island of Skye, so isolated that it is approached only by a footpath, hold the dentistry record of Scotland.
>
> "On his last inspection, Mr. W. J. Inglis, the dental officer of Inverness-shire Education Authority, failed to find a single tooth that showed the slightest defect."
>
> "There is no doubt" he states, "that the natural food of the children in these lonely island districts is the chief factor in the preservation of their teeth. Many of them do not eat a single sweet from one year's end to the other, and the contrast between them and town children is so marked that it is impossible to overlook the moral."

The *British Dental Journal* had a somewhat different way of looking at the subject. It acknowledged that the dental officer referred to, did not find a single tooth among them which was carious. Rather does it try to find an explanation

"in great measure to the energetic propaganda of the head mistress. . . ."[4] Nothing is mentioned with regard to the sweets that were or rather were not eaten. So let us pass on to another community where there is no head mistress for the children.

The lonely island of Tristan da Cunha gives us what might be called an unbiased experiment. Remarkable results were recorded. The dental condition was made the subject of special examination by Mr. J. R. A. Moore, President of the Dental Society of the Cape Province, in cooperation with the Surgeon Lieutenant Commander of the Royal Naval Hospital, Sincons Town.

> "Islanders to the number of 156 were examined ranging in age from infancy to ninety-two years, and of these the teeth were found to be entirely free from decay, and the general condition of them could only be described as perfect. . . . The staple diet of the people, it was determined, was potatoes, fish, milk and eggs. . . . Large quantities of milk and cream the report says, are used, but as a matter of fact there are frequent shortages of these. What, however, has special significance, we are told, in the mode of diet of the people, is that they never eat more than one kind of food at a time, and this as Bishop Watts says may be the reason for their perfect health. . . .[5]
>
> "In continuation of the correspondence in *'The Times,'* which followed, 'M.D.' has a letter in which he expresses the opinion that the explanation of the perfect condition of the islanders teeth is to be found in the fact that, as mentioned in Mr. J. R. A. Moore's report, 'sugar is hardly ever used; they can get it only from ships.' He says: 'The view that sugar is the cause of decayed teeth . . . . was rapidly gaining ground until the Medical Research Council decided that the disease was due to lack of vitamins, and thereupon set about to investigate the point. Many thousands of pounds have so far been spent on this investigation and, so far, in my opinion, the results show that sugar is the cause of caries and that vitamins have little or nothing to do with it'."[6]

Further observations with regard to sugar, vitamins and milk are to be found in D. M. Gane's book on Tristan da Cunha which will well repay perusal. But here it may suffice to quote the following paragraph from M. D.'s letter to *The Times*. Therein he says:

> "For many years I lived in Northern Rhodesia and can guarantee that in the bush native—that is, one far removed from European stores—there is no primary decay of the enamel of the teeth . . . . on the other hand, down in South Africa, in the Transkei, for instance, where the European stores supply the native with unlimited sugar, I have occasionally seen native children with every tooth in their mouths decayed."[7]

In Tristan da Cunha, and we have it on the authority of Mrs. Rose Rogers who spent three years there,

> "There are no infant foods at Tristan, and the mothers nurse the babies themselves, very often until the sixteenth month or over. And the islanders are very good to the young, and their supply of milk comes first."[8]

I need not refer to my own views as about this time a fairly long paper was published in the July number of the *Journal of the American Dental Association*.[9] Moreover they differ little or not at all from my present views but the question of the expenditure of many thousands of pounds on useless investigations by the Medical Research Council to which "M. D." referred should be noted, especially as this Council consisted of medical men without dental qualifications.

Incidentally the *British Dental Journal* for June 6th, 1947 revealed the fact that the amount of £698,000 had been allocated by the Government for Medical Research. No doubt the "Spectacular Improvement"[10] which has recently been noted resulted from the rationing of sugar and sweets, together with including much of the offal or husk of the grain and the addition of innutritious prepared chalk which has for the last half century been recognized as the basis of many dentifrices. According to W. Hale White, author of *Materia Medica Pharmacy, Pharmacology and Therapeutics,* that when prepared chalk is taken internally

> "very nearly all of any calcium salt is excreted unchanged in the faeces. When calcium salts are taken, small quantities are absorbed; most of that absorbed is excreted by the epithelium of the large intestine, the rest by the kidneys. Calcium is necessary for all forms of protoplasm."

Consequently if deprived of milk and all other foods containing protoplasm the results will be disastrous. Since 1903 at least however, I have recognized that the

> "The food of children should be of a chemical composition, such as is found in milk, and such as is advocated in text-books dealing with this

subject, but the physical characters of the solid food should diverge from that of milk in proportion to the number of teeth erupted."[11]

This generalization seems to be much more explicit than speaking about an abundance of fat soluble foods and "adequate" amounts of different ingredients in the dietary.

Bearing in mind the chemical and physical nature of the different sugars noted in the first part of this chapter need we be surprised to learn that the addition of a few spoonfuls of milk containing "a gritty powder of moderately sweetish taste" would transform a "purified diet" devoid of these and other stimulating factors into a sufficiently wholesome diet to maintain life and health; it has been frequently contended from 1900 that fibrillar cellulose stimulates mastication as likewise do other innutritious ingredients such as are found in the cortex of grain. What indeed could we expect to be more beneficient than suitable innutritious substances to stimulate mastication and the muscles whose function it is to cause peristalis from one end of the alimentary canal to the other, not to speak of the various mucous and other glands which facilitate the mechanical as well as the vital activity of the phagocytes? Before attempting to sum up the pros and cons of the views brought forward in the first two decades of the present century, let me say with regret that advancing years and failing eyesight interferes to some extent with writing a full epitome of the subject, or digress and criticize opponents who were apparently but little acquainted with hygiene in diet having special reference to the teeth, mouth and alimentary canal, such as would compel them to note the progress which the new ideas had made during the first two decades of the present century. Suffice it here to say that highly distinguished members of the dental profession were well aware that researches were being made founded on eccentric feeding of animals many years before the alluring catchword "vitamin" attracted much attention and "struck the imagination of the public." Indeed it may be said that the trend of real progress was unknown to all but a very few medical men in the early years of this century. Yet it certainly came to be fully recognized by well informed members of the dental profession. Thus at the annual meeting of the British Dental Association in 1909 the gist of the newer knowledge of hygiene in diet was incidentally introduced in a communication I gave, entitled: *"The Addendum Prandii and Professional Education."* In the discussion which followed the late N. G. Bennett, M.A., M.B., Ch.B., L.DS. (now better remembered as Sir Norman Bennett) said he

> "agreed with every word of the paper, especially that part dealing with young children which was unfortunately left mainly in the hands of medical men."

In the following year Sir Frank Colyer paid ample tribute to the newer knowledge in his well known textbook on *Dental Surgery and Pathology*. Then in 1914 *The Science and Practice of Dental Surgery*, edited by Sir Norman Bennett, appeared. In the chapter on Oral Hygiene and Preventive Treatment of Dental Caries, E. B. Dowsett, M.R.C.S., L.R.C.P., L.D.S., who was chosen to write this chapter referred to "The Natural Means of Cleansing" of the mouth and teeth and stated that

> "the whole question was summed up in the following words: If children are fed according to physiological principles, while hygiene requirements are not neglected the teeth will not decay, nor will the other diseases which result from the infringement of physiological laws be at all likely to be prevalent."

He also referred the reader with approval to the chapters in Bennett's book which had been entrusted to me to write.

About the same time Sir Harry Baldwin in his presidential address to the Metropolitan Branch of the B.D.A. said with regard to hygiene and prophylaxis of dental and alveolar disease, that

> "to him the outlook was very bright in this direction, and presents the most attractive side of dental surgery of the present day. An elucidation of the etiology of dental disease and of immunity from it is the most important issue of dental science, but we know enough to renew with fresh vigor the campaign for the prevention of dental caries and oral sepsis. Our friend Sim Wallace, has done more than anyone else to remove obstacles to our seeing clearly what should be done in this direction. . . ."[12]

What more he said can hardly be repeated, even in an autobiographical epitome of the subject such as I have been making. Then in his presidential address J. Howard Mummery, D.Sc. (Penn.), M.R.C.S., L.D.S., England, at the Sixth International Congress in London said:

> "Whatever difficulty there may be in attaining to a clear understanding of all the predisposing causes of caries of the teeth, there is no doubt that the determining cause is carbohydrate stagnation; the fermentation which takes place in retained particles of food by the agency of bacteria present. As repeatedly pointed out . . . . food containing its fibrous constituents favours efficient mastication and has a direct cleansing effect on the teeth."

Similarly J. H. Gibbs, F.R.C.S., L.D.S., Edin., Late Honorary Dental Surgeon to the King in Scotland wrote a paper on "Child Welfare and the Prevention of Dental Disease" in the *Edinburgh Medical Journal* in 1917, saying:

> "Of great interest to us who are seeking a solution of the problem of dental caries in the children of the masses, is the fact that a sufficiently large number of children have been brought up on the lines laid down by

Sim Wallace to prove that under modern civilized conditions dental caries can easily be entirely prevented or almost entirely prevented."

Then in the *Dominion Dental Journal*, April 1914, a paper entitled "Observations on the Prevention of Dental Caries" was published giving a short historical sketch of various theories

> "to explain the 'Chemico-Parasitic Theory' announced by Dr. Miller in 1885, which is now almost universally accepted, as the most satisfactory explanation of all the phenomena."

In the discussion which followed Dr. A. E. Webster, M.D., D.D.S., L.D.S., Editor of the *Dominion Dental Journal* referred to my books which he said

> "really bring about some of the ideas better than Pickerill's. I met Sim Wallace last year in Glasgow. He is in that unfortunate position of being a Scotchman in London . . . . but he is looked upon as being by far the most advanced in the study of the prevention of dental caries."[13]

I could give further tributes to the attitude of highly distinguished authorities though not dentists such as Sir Truby King, Dr. Harry Campbell and others who have devoted time and thought to the ideas indicated in this review of the subject, but enough has been said to exhibit unanimity of the prevailing opinions of well-informed dental surgeons.

Naturally since the theory has been authoritatively accepted there has been a certain amount of opposition from those whose views were discarded. Moreover, there have always been those who could not be bothered with a theory which presented some trouble in its application.

Knowledge and patience are necessary in unraveling the results of dietetic error which are often presented to us. No two foodstuffs are the same, and even although we may classify foods as lodgeable and fermentable on the one hand, and detergent on the other, there are very considerable variations in such characteristics in both classes. Nor have we simply to deal with one particular foodstuff at a time. In the diet of almost everyone the detergent and lodgeable types are so inextricably associated, that it is in many cases well-nigh impossible to come to any conclusion with regard to the share different articles of diet have in the occurrence of the disease. It is, indeed, only when some long-continued error is pronounced, and not counteracted by detergent foods, that we are able to show clearly the truth of our theory. The arrangement of the meal requires, as a rule, to have consideration even when there is not supposed to be any arrangement in it at all. Then, again, what we may call the static variation in the teeth, such as the depth of crevices, abnormal pits, faulty arrangement, and receding gums, have to be taken into consideration. Lastly, variations in the physiology of oral hygiene in different people must receive their share of attention. These are seldom or never noted by those who look for some mysterious immunity in the substance or texture of the teeth when they do not succumb to destruction resulting primarily from the action of bacteria and the acids formed from carbohydrates which are retained in stagnation areas of the teeth.

Mr. F. Breese[14] showed that the amount of lodging food in different children's mouths varied greatly, even though the actual food eaten was the same. The varying amount was observable when the meal was finished. The quickness of the self-cleansing process indicated that this was largely mechanical, depending on the arrangement of the teeth and on the cleansing action of the tongue, cheeks, and lips differing in different children.[15]

Now let us examine the essentially different theory based on the vitamin hypothesis which was taken up about six years after Funk introduced the word vitamin and "struck the imagination of the public."

As already noted in Chapter VXI a communication was contributed by May Mellanby, in which it was said that this is an instance of diet affecting the teeth from the inside and is independent of bacterial sepsis and other conditions associated with food. Quite so, but what about the implications that dental caries, irregularities, and hypoplasia were due to a deficiency of fat-soluble vitamins in the ordinary diet of school children among the more highly civilized communities of the world?

Apart from contending that the chemico-parasitical theory of the causation of caries was of but little importance she omitted to note that it was at first really only research workers whose imagination had been struck in Britain at least, and even the Royal Society bedazzled itself with the supposedly brilliant results.

It had long been my contention that we could not judge foods properly by their caloric value and that accessory food factors such as physical consistency, viscosity, lodgeability, fermentability, acidity, etc., must be taken into account, so at first I rather welcomed vitamins. But with regard to fat-soluble A, I began to see it looming too large on the horizon. That it might be the cause of rickets may not have disturbed me, but when it was claimed that lack of fat-soluble A was the fundamental cause of rickets, dental hypoplasia, and dental caries, I began to think investigators must be peculiarly ignorant of the researches which had been carried out long years ago. Distinguished dentists[16] had, of course, thought of the possible association of rickets and dental caries, but their investigations negated the idea that there was any special association, and clinical evidence did not lend much if any support to the view. Moreover, some fifty years ago Black's memorable investigation showed that the calcium content of the teeth had nothing to do with predisposition to dental caries. Nevertheless Professor Halliburton, in 1921, while speaking of rickets, referred to the condition of "bad teeth" as closely allied to it.[17] Professor Mellanby made similar implications, and even as late as July 1922 said that the "eradication of rickets . . . . would improve the teeth of the people of this country beyond recognition.[18]

Many years ago we had considered that hypoplasia might occasionally result from rickets, but, of course, as a cause of the widespread prevalence of caries it is quite negligible. I have no time to refer to the sorry fate of the original fat-soluble A theory of the causation of rickets; nor to the collapse of the original fat-soluble A theory of dental hypoplasia and caries. You know that the experimental deficiency diet which was supposed to have produced the hypoplasia was given after the hypoplasia had taken place; that the hypoplasia became cured during the deficiency diet; and thanks to the investigation of Mr. A. T. Pitts we were able to show that, even supposing hypoplasia might be caused by this deficiency diet, it could only be held to account for one carious tooth in 10,000 in temporary teeth.[19] Microscopic substitutes for the fat-soluble A theory of hypoplasia need hardly be considered, and Mrs. Mellanby's modest claim that her work shows Miller's chemico-parasitical theory to be "comparatively unimportant"[20] may be passed without comment.

Although this vitamin theory revived the old untenable and discarded belief that the incidence of caries depended on the quality of the tooth itself, we may comfort ourselves that the discredited experiments and views have undermined the other untenable hypotheses; in fact, we appear to be getting tired of anything but the simple truth, and it is pleasant to note that even those who espoused the vitamin theory have now acknowledged we were "right from the first,"[21] while those who "continued quietly teaching and standing by the truth first and long ago discovered"[22] in England have been acclaimed for their work in furthering the cause of preventive dentistry.

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# Chapter XVIII

## DISCUSSIONS AND REPERCUSSIONS 1921-1930

What is now generally referred to as the Newer Knowledge of Hygiene in Diet was introduced in 1900 and until the end of 1918 gradually became established. We recognize, however, that the nutritional or vitamin theory which "struck the imagination of the public" was definitely introduced toward the end of the second decade of the present century, i.e. some six years after Casmir Funk coined the catchword "vitamine," It recalled some ideas based on experiments on animals which neglected to recognize the elementary truths which had been established by such eminent authorities as Sir Henry Thompson in his book on *Food and Feeding,* (1899), and scientists in the dental profession who had established the fact that dental and alimentary hygiene depended on the chemical and physical qualities of food which prevented unhygienic conditions in the mouth, about the teeth, and indeed throughout the whole length of the alimentary canal.

The discordant note resulting from research on animals, and the misleading catchword vitamin, became very evident when in 1921 a book was published entitled *The Gateway to Health.* (Edited by Charles E. Hecht, M.A.). This book gives the views of eminent medical and dental authorities who had given special attention to oral hygiene and the prevention of dental caries. I have referred elsewhere to the work of Dr. Harry Campbell, Dr. James Wheatley, W. D. Miller and others. Here I would say merely that the Food Education Society rendered a great service to humanity in bringing the different views together and giving full opportunity for evaluating the relative value of the different schools of thought. In his inaugural address at the Manchester Congress* J. G. Adami, M.D., F.R.S., Vice Chancellor, University of Liverpool, commenced as follows:

"I want to take for my text certain words of a very dear friend of mine, the greatest physician of our generation, the late Sir William Osler. 'You have got, said he, 'to preach it early and late. It is the gospel of the cleanliness of the mouth, cleanliness of the teeth, and cleanliness of the throat.

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*May 14th, 15th and 16th, 1920.

There is not a single thing more important to the public in the whole range of hygiene than that. It is a matter of really national importance.'

"With that gospel I am wholly in agreement. May I put before you certain aspects of the matter that claimed my attention when I came back to England in 1915 as a member of the staff of our Canadian Army Medical Corps? . . .

"In wandering through London streets and English towns and villages, a profound impression was made upon me by the extraordinary amount of evidence on every hand of the wretched state of most people's mouths. Men and women had only to smile to exhibit what, compared with my experience in Canada, was a perfectly ghastly series of decaying fangs. Gaps where good teeth should have been, and front teeth irregular, discolored, eroded, and evidently utterly uncared for. . .

"I do not wholly like the variegated golden smile that too often confronts one over in America. Still, the abundant evidence there of filling and crown and bridgework does at least show that care has been taken. It is quite possible also that, being more nervous and highly strung, those of the North American continent are forced by mere physical agony to go to the dentist, whereas we more phlegmatic Britons can have our teeth worn away with disease without being specially disturbed. Here the mass of the population take little or no care of their teeth, and sooner or later this must have its inevitable result in impaired general health."

WHY THE FOOD EDUCATION SOCIETY IS NEEDED.—DR. HARRY CAMPBELL, Vice-Chairman, Food Education Society, said;—

"In the unavoidable absence of Dr. Beckett-Overy, Chairman of the Food Education Society, it is my privilege to move a vote of thanks to Lady Rhondda, who has so graciously come all the way from London to open this Conference, and to Professor Adami for his most interesting address.

"I would take the opportunity of telling you that the Food Education Society has no fads, no eccentric fancies in the matter of diet. Our object is to discover what is the best kind for the community and to put the public in possession of useful knowledge.

"The British, in my humble opinion, are the worst-fed people in the world, and an incalculable amount of disease could be prevented if they were fed on proper lines.

"A WORLD WITHOUT DENTISTS.—Chief among the many evils resulting are diseases of the teeth, about which Sir William Milligan and Professor Adami have spoken. Personally, I am not greatly interested in the questions which Professor Adami has raised. I am not concerned about increasing the number of dentists. I really do not care much about his dentists! What I want to see is the prevention of dental disease, and that is what we are out for. Professor Adami wants to multiply our dentists. I want to reduce them to a minimum. We are convinced that nine-tenths of dental disease is preventable. The object of this congress is to instruct the public how they can reduce diseases of the teeth by nine-tenths."[2]

I need not refer to the many notable papers delivered at this congress, but that it marked a great advance in the progress of our knowledge with regard to prevention of dental diseases and others associated therewith is indubitable.

We may now turn to some events which occurred in the third decade of the present century. The state of affairs at this time may be indicated by a letter from F. M. Holborn, L.D.S.R.C.S., in the *British Dental Journal* (May 1st 1921) prefaced with the headline "Causation and Prevention of Dental Caries." It was not controversial and after congratulating me on a short article in the April number of the *British Dental Journal* he referred to the fact that several years before this I bought my elder son, who was

> nearly twelve years of age, to a meeting[3] "and exhibited the perfect dentition consequent on observing the natural principles of a detergent diet. Other dentists, including myself, have obtained similar results by similar means. I, in my youth and inexperience, imagined that the last word had been said, that all dentists thenceforth would preach the gospel of 'The Mouth its own cleanser,' and that gradually the public would learn that in a return to a simpler and more natural diet dental caries would be eliminated. I was wrong. There was something too sublimely simple in Dr. Sim Wallace's theory to appeal to a learned profession. It is not enough that here and now any child, whatever its inherited characteristics and metabolic idiosyncrasies, can be brought up with a caries-free mouth.
>
> "Our earnest faith in toothbrushes, powders and antiseptics remains unshaken despite their obvious failure to accomplish the same object; veneration for the laboratory worker dims our appreciation of a fundamental fact, so obvious that we do not trouble to grasp it; and the glamor of those blessed words 'fat-soluble A' and 'water-soluble B' suffice to comfort our consciences until some others, equally euphonious and erudite, shall supplant them in our affections. Present day efforts appear to deal more with the variation in individual tendencies than with applying the well-established and unchanging law that any mouth already free from caries can be kept so by arranging the diet so that at the end of each meal the teeth are clean. There may be predisposing causes of the lodgment of fermentable carbohydrates upon the teeth.
>
> "I am not scoffing, Sir, at the earnest seeker after Truth, rather am I blaming those who, having heard Truth, do not spread it broadcast among their patients to the immeasurable advancement of public health and the dignity of the profession. The problem of the cause and prevention of dental caries was solved years ago, and its truth may be re-proved by anyone who cares to read Dr. Sim Wallace's writings, and put into practice the precepts there found. . ." (Signed F. M. Holborn).

How far the newer knowledge of hygiene in diet had progressed in the early years of the third decade of the present century may be indicated by the adoption of a "Leaflet for the Use of Parents" which was approved by the Council of the Society of Medical Officers of Health. This leaflet has already been published in *Dental Items of Interest* (Oct. 1930, pp. 170-1) and need not be repeated but it may be well to give a recapitulation of the principles which are now "more or less universally accepted"[4] by the dental profession.

(1) Except as the result of disease the quality of the enamel and dentine or of the saliva and mucus have little or no influence on the initiation or progress of dental caries.

(2) The prevalence of caries in modern times, especially among the more highly civilized, is not due to deficiencies in the essential elements in nutrition.

(3) Caries results entirely from the action of bacteria and acids formed from foods, especially sweets and sugary foods which periodically lodge in certain retention areas about the teeth. Acid-producing bacteria, as also organisms promoting gummy fermentation, are induced to proliferate by food of a sugary nature.

(4) In order to attain the concentration of acid necessary to attack the enamel or permit weak acids to do this, the food and saliva mixture must be of such a nature that the acid formed will not be counteracted by the ingress of fresh saliva.

(5) Foods, or bacterial products, of a viscid or gummy nature tend to prevent the ingress of fresh saliva, as likewise do such foods prevent the egress of acid formed by bacteria.

(6) In the human mouth, if the teeth are unbroken and the arch normal, even carbohydrate foods of a granular or reticulate nature, through which saliva can pass easily, do not have much opportunity of causing caries. Consequently, vegetable foods, including cereals, when fresh or even though cooked without sugar, seldom tend to induce caries; even when not of a consistency which stimulates mastication they may help to avert the disease.

(7) When vegetable foods are associated with substances which stimulate mastication and salivary secretion, e.g., those firm in texture or, if containing acid, aromatic or tasty principles, the likelihood of caries resulting is still further decreased.

(8) Tastes, or dietetic habits, e.g., modes of mastication, and the movements of the tongue, lips and cheeks, which tend to keep the mouth in a hygienic state by physiological means, are highly important in averting caries.

(9) Formed enamel is inert and so cannot undergo change due to metabolic processes. Such changes as occur in it are of a chemical or physical nature. The enamel cuticle protects the enamel from food acids in transit through the mouth, but does not prevent acid (formed from bacteria) which may remain in prolonged contact with it from initiating caries. The residual organic fibrils which pass from the enamel cuticle through the interprismatic enamel substance facilitate percolation of acid from the external surface to the dentin. This is specially noticeable in the lamellae, which may also be regarded as remains of guy ropes maintaining correct relationship of the limiting membrane or sheet of cells on the outer surface of the forming enamel to the dentin.

(10) The proteolytic bacteria are primarily outside the enamel and act antagonistically to the acid-producing bacteria. The products do not decalcify enamel, though after a breach has been made the proteolytic bacteria take a share in the destructive caries process. Chromogenic microorganisms tend to be associated with proteolytic fermentation or putrefaction as also frequently is the formation of tartar, so that teeth strikingly dirty in appearance may be well protected from caries.

(11) In addition to foods of an albuminous nature, serum, phagocytes and salivary corpuscles are antagonistic to the action of acid-forming bacteria.

(12) The sequence of the foods in a meal may influence the control of caries to some extent if the meal is not wholly composed of detergent foods. When sugary foods are eaten a cleansing food at the end of the meal tends to act as a liberating stimulus to the self-cleansing processes, both mechanical and chemical.

In 1925 the results of an extensive investigation were given in an Anthropological investigation carried out in Australia. The title of the book is *Dentition and Palate of the Australian Aboriginal.* This was a thesis presented for the Degree of D.D.Sc., and published by the University of Adelaide under the Keith Sheridan Foundation. "The book is of outstanding importance to the dental profession, to the science of anthropology and one which will satisfy the requirements of the scientific dentist and expert Anthropologist for many years to come."[5] (In page 82 of his book Dr. T. D. Campbell makes a highly appreciative reference to my line of reasoning as being "after all the most reasonable and obvious one to adopt. The problem of the causes of dental disease and irregularities is not one calling for long and intensive research, but a simple lesson which the present study should help to make reasonably clear.")

Another highly important contribution with regard to "The Temporary Dentition in Health and Disease" to which chronologically I should have referred, was read at the Manchester Congress by A. T. Pitts, D.S.O., M.R.C.S., L.D.S.,[6] in which he refers to the Rarity of Defects, saying:

> "The care of the temporary teeth really commences before birth, since the deposit of lime salts in them, which makes them hard, begins before the child is born. It might be thought, considering the adverse conditions under which many mothers live during pregnancy, working when they should be resting, often with an insufficient supply of nourishing food, that so highly complex a process as calcification would be affected and that the teeth would show structural defects. Actually this is not so and defective formation of the temporary teeth is rare. Over a large and extended experience of many years, I have only been able to collect a few cases and not more than one per cent of children show such a condition. We may say, therefore, that, in the vast majority of cases, the temporary teeth come through well formed and that prenatal conditions, so far as their structure is concerned, play only a small part in predisposing to their destruction by dental caries."

It might have been unnecessary to recall further events in the latter half of the third decade of this century, but it would certainly be inexcusable to omit a reference to the lecturing tour which my colleagues in America arranged with most generous hospitality not only to me but also to my wife. I appreciate with Dr. John E. Gurley that "it was quite a stupendous undertaking to fit the desires and the wishes of each of the dental societies in U. S. A. and Canada into an unbroken chain, and arrange a schedule so that a minimum of time might be lost and a maximum given to our guest and his hosts at each point."

For the first of three addresses delivered at some twenty-four of the most important dental and medical societies in Canada and the United States I chose for my subject, *Preventive Dentistry in England and our Debt to the Dental Profession of America.* This address began as follows:

> "Before venturing to give you an address on Preventive Dentistry I really must thank you for the great honor you have done me. I can assure you that your invitation and your generosity in bringing me and Mrs. Sim Wallace to America are deeply appreciated, and it is difficult, if not impossible, to thank you sufficiently. To be invited by one's own colleagues in other lands to appear before them and give an address is surely the greatest compliment anyone could wish for. But to be invited to do this in the very heart and home of progressive dentistry carries the compliment to the verge of embarrassment. I quite recognize, however, that it is not upon questions relating to dental surgery as an art that you wish to hear me speak, since in this you in America hold a position of pre-eminence justly recognized throughout the civilized world. It is rather, I understand, my work in relation to the physiology of oral hygiene, and the pre-

vention of the diseases of the teeth, about which you would like to hear me talk.

"Although preventive dentistry, based on scientific principles, may be regarded as of recent origin, a certain amount of knowledge, together with empirical customs which aimed at the prevention of dental disease, has undoubtedly existed for centuries. The toothbrush is not a modern invention, and the exhortation dates back for three centuries. Before the middle of the last century, however, the dental profession had commenced to give serious consideration to the scientific study of dental caries, but although many facts of importance were brought forward and great advances were made, it is to the more modern work of three world-famous American dentists that I would specially refer, for it is largely upon the principal parts of their work that preventive dentistry in England is based.

"It might be possible to form a theory with regard to the causation and prevention of dental caries without having a knowledge of its nature or pathology, and on the other hand, although we knew the pathology of the disease, it would not necessarily follow that we could explain its etiology. Nevertheless, this knowledge which we now possess certainly allows us at least to discard many theories which even at the present day are all too prevalent. It is to the work of the late W. D. Miller that we are indebted for the thorough elucidation of the nature and pathology of dental caries. It is true that much excellent work had been done before Miller took up the subject, particularly perhaps in France, for much of the chemico-parasitical theory was dependent upon the elucidation of the nature of fermentation by Pasteur, and the experimental production of caries by Magitot cannot be overlooked. It is, of course, unnecessary for me to refer to Miller's work on this subject. It is familiar to you all. There is only one point I should like to make. Miller elucidated the subject so thoroughly and defined the nature of caries so precisely, and in this we have all followed him so implicitly, that anything which does not conform to his definition we simply do not admit to be dental caries at all. It is only necessary to refer to this because in recent years experiments have been made which have been claimed to indicate that 'caries-like' lesions have been produced in certain animals by processes other than chemico-parasitical, origin, they are simply not caries, nor have they the slightest or the remotest resemblance to the essential facts associated with caries.

"You are all familiar with the knowledge that the dental profession owes to the late Professor G. V. Black. But it is only his epoch-making 'Investigation into the Chemical and Physical Characters of Teeth' to which I would here refer. In this, you will remember, he showed that the molar teeth were more fully calcified than the incisors by about two per cent, though molars are from 6 to 30 times more subject to decay than the incisors. The accuracy of this analysis was confirmed by Sir Charles Tomes in England, and Black concluded that 'neither the density nor the percentage of lime salts, nor the strength, is in any degree a factor in predisposing the teeth to caries, or in hindering its inception or progress.' In another way Tomes further confirmed Black's findings. He analyzed two sets of teeth to ascertain the percentage of salts. 'In one set the third molars were largely affected by caries, and incipient decay existed between many of the teeth; while in the other set, although much worn by attrition, the teeth were quite free from caries. The analysis gave 71.4 per cent of salts in both cases.'

"Yet even to the present day theories based on misleading experiments on animals are brought forward to explain why the teeth are not sufficiently or properly calcified, and these demonstrably erroneous suppositions with regard to calcification are actually claimed to be the fundamental cause of the prevalence of dental caries! In view of the verified facts, could anything be more misleading or a greater waste of time?

"Let me now refer to the microscopic structure of the enamel. Dr. Leon Williams in his unexcelled research on the pathology of enamel[7] showed that defects in structure, 'such as pits, grooves, fissures, pigmentations, granular and amorphous enamel, are common in the lower animals,' whose teeth we know are practically free from caries. With the aid of the finest lenses, and the highest magnification, added to his own almost inimitable skill and care in the preparation of sections, he was unable to discover any difference or degenerative change in the microscopic structure of the enamel of the teeth of modern civilized man, as compared with those of his remote ancestors of thousands of years ago. He noted, too, that in his judgment 'the more imperfectly formed teeth so far as inherent structure was concerned (and he meant by that the proportion of lime salts which were contained or anything other than the grosser defects such as were found in enamel in a perfectly healthy mouth) would never decay,' while 'in an unhealthy mouth (and by unhealthy he meant those conditions inimical to the preservation of the teeth) the most perfectly formed tooth would never be able to resist decay.' Of course, we dentists are all familiar with the obvious, we all frequently see hypoplastic teeth which have not decayed throughout a lifetime, while we see the most perfect teeth gradually becoming ravaged by the disease. Indeed, in one and the same mouth we often see hypoplastic incisors persisting in not becoming carious, while the premolars and second molars, though perfectly formed and free from hypoplasia, succumb to decay.

"Now consider the enamel from the chemical point of view. It has long been supposed that it contains little or no organic matter. With the best technique that science can devise, however, it is estimated that enamel contains about 1 per cent of organic matter.* Now what and where is this 1 per cent of organic matter in the enamel? According to Dr. Leon Williams, it is to be found in the prism sheath, and as regards its composition we are indebted to Professor Gies for the knowledge that it is of a protein nature, presumably a sclero-protein like Nasmyth's membrane, which, as he has indicated, possesses considerable elasticity. We can readily see that in the enamel this is of considerable value from the physical point of view, and it might well be regarded as a sufficient explanation of its presence and utility, but some investigators are greatly intrigued by this 1 per cent of organic matter. They assume that it possesses some wonderful vital power. Some even claim that the highly complex phenomena associated with immunity in the blood may be possessed by this 1 per cent of organic matter which is firmly embedded in the inorganic enamel."

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*This was written about two years before the publication of Messrs. Sprawson and Bury's investigation, which, of course, strengthens the argument I am here using. See Oral Hygiene and Recent Research, Second Edition, by J. Sim Wallace, Chapter X, pp. 171-2.

A few years after my appointment as lecturer on Preventive Dentistry at King's College Hospital it was my good fortune to be persuaded by Professor D. Fraser-Harris, M.D., D.Sc., F.R.S. (Edin.), the General Editor of *The Modern Health Books*, to write one of the volumes of the series. His tribute to my work, given in the Editorial Introduction, perhaps aroused the idea that a like procedure might be followed by The Dental Board of the United Kingdom. Anyhow in the year following the publication of my book entitled *Teeth and Health*, the Dental Board of the United Kingdom published a book on the *Hygiene of the Mouth and Teeth*. It was beautifully got up and well illustrated. In the Introduction by the Chairman of the Board the Rt. Hon. Sir Francis Dyke Acland (appointed by the Privy Council), commenced as follows:

"This book is primarily intended to help teachers to help those they teach to that best foundation for good learning, namely, good health" . . . He concludes by saying: "The book, I should have said before, is a compilation, for parts of which I am greatly indebted to colleagues on the Dental Board; and for part, and for admirable help throughout, to Dr. H. C. T. Langdon, Medical Officer of the Board of Education. . . The work throughout has been for us all (perhaps needless to say) a labor of love, in which I am conscious of having borne for the least part, (signed) Francis D. Acland."

It is not my intention to review the views, good, bad and indifferent, expressed in the book published by the Dental Board for although as I have said, vision was obscured by the vitamin fog, individual writers have not overlooked the importance of the detergent diet in the prevention of caries. A number of books on the feeding of children have been published during the second and third decades of this century each in its own way emphasizing the benefits of the detergent diet theory, while certain encyclopedias[8] contained numerous articles, on various subjects associated with the teeth which kept as strictly to the dietic doctrines I advocate as anyone could wish for. Indeed, well considered and authoritative information was broadcast, not only throughout Britain but also throughout the whole civilized world.

Let me refer to two of the most important of these. Notwithstanding his introduction to *Hygiene of the Mouth and Teeth* published in 1927, Sir Francis D. Acland made a broadcast which was issued at the request of the Dental Board of the United Kingdom. This, in addition to being published in the ordinary way, was produced in the form of a gramophone record by the International Educational Society. The whole address is simple, straightforward, wholesome instruction well suited for its purpose. Here I can only refer to what he said with regard to diet and eating.

"Teeth must have exercise, particularly while the jaw is growing. A little child with only four teeth should be given crusts of wholemeal bread to chew now and then. From childhood onward, no one should ever end up a meal with anything that leaves a sticky paste on the teeth like cake, buns, pastry or sweets. As to sweets, a doctor went the other day to one of the islands of the Hebrides, and gave lectures on the care of the teeth in the schools, and he found that the only place where the children's teeth were bad was a village where there was a sweet shop! Finish a meal with oatcake or wholemeal bread with plenty of butter, or better still with fruit or uncooked vegetables, such as lettuce—and an apple is best of all. Never, never should a child have a biscuit or chocolate or anything else when it has gone to bed for the night."

I sent the full address as it was published to a friend who had been taking an interest in the subject for many years. His comment on it was,

"Where have the vitamins fled?"

The other authoritative epitome of our views to which I would refer is the leaflet brought out by the Society of Medical Officers of Health, and issued by the People's League of Health. This was prepared by a committee, elected by the council from the various groups of the society. Though the committee was appointed when the vitamin craze was in full blast, a little quite occasional discussion, continuing for about two years, interrupted by an incident resulting from the existence of the Medical Research Council that seemed likely to wreck the whole affair, brought the committee to unanimity. If other individuals would similarly sit down to a little quiet consideration of the facts of which we are already possessed, there would, I think, soon be an end to the school of thought which has during the last dozen years militated against the diffusion of knowledge so urgently required for the prevention of the disease of the teeth and all the troubles of concomitant and consequent origin.

The last book to which reference may be made, published toward the end of the third decade (1927), was entitled *Variations in the Form of the Jaws, with Special Reference to Their Etiology and Their Relation to the Occlusion of the Dental Arches*. It was rather long. There were numerous illustrations and detailed measurements with regard to the growth of the jaws and arrangement of the teeth in a subject who was brought up on the lines which are recommended in all of my books and communications. But although it was, I believe, important from the point of view of oral hygiene, dental caries, tartar, pyorrhea and facial beauty an attempt to deal with it briefly would probably not be very satisfactory. So I will only submit the criticisms of two famous anthropologists. I had the pleasure and good fortune of meeting the Editor of the *American Journal of Physical Anthropology* (the late Dr. A. Hrdlicka) during my visit to Washington, and again while he was in London on the occasion of his giving the Huxley Memorial Lecture. From our conversations, from his contribution to the discussion of my paper in Washington and the review in the journal referred to, I gathered that we were in remarkable agreement with regard to many points on which some distinguished anthropologists appear to differ. Omitting some comparisons with other literature, etc., the following extract from his review indicates his opinions:

> "In many aspects the work is of direct interest to anthropology. . . There are many good observations, based on original research by the author. A few examples must here suffice. Under normal conditions there is a close correlation between the size of the teeth and that of the jaws; and mixture of races appears to make no exception in this respect. The dental arches of the more primitive peoples show remarkable absence of these irregularities which confront us in civilized man today. Rachitis does not perceptibly affect the development of the jaws. The tongue plays an important part in moulding the dental arches. The growth of the jaws, as that of other bones, does not proceed evenly throughout its course. Pressure strains act chiefly in stimulating growth in breadth. The factors which tend to cause narrowing of the palate operate, it is highly probable, very early in life. After the milk teeth erupt, practically all the horizontal growth of the jaws is behind the second milk molar. The chin is 'an appearance resulting from the decreasing size of the dental arch,' it being placed as a whole farther back in the relation of the body to the jaw. It is difficult to accept the view that the chin has been modified in form to facilitate the production of articulate sounds. Normally, variations or fluctuations in the size of the teeth or dental arches tend to take place en masse. Among the civilized men of today there is observable a reduction in the size of the teeth, and this feature is generally beneficial. It is an illustration of a relatively rapid evolution to meet the altered requirements of the civilized environment, etc. In addition to its morphological parts, the book includes much sensible discussion on vitamins, hormones, and the causation of dental and jaw abnormalities. The illustrations are very good throughout. They include, as a special and rare feature, a series of casts of a very nearly perfect denture developed by a son of the author under the latter's guidance as to food and the use of the jaws." (*The American Journal of Physical Anthropology,* October-December, 1927).

Several points in my book give interpretations of certain questions differing materially from those held by Sir Arthur Keith. I ventured to criticize adversely several of his observations and opinions, yet, in the following extract from his fairly long review of my book in *Man* (November, 1927, pp. 210-212), it may be seen that he appreciates criticism, like all good scientists, which may be helpful to the full elucidation of the subject:

> "At present we are using methods which are too crude to bring out and express the precise manner in which races differ in form of face. We have to find such methods on a full knowledge of how the face grows and the exact part which each structure of the face plays in the physiology of the whole. Therein lies the value of this work by Dr. Sim Wallace: it deals with the growth of the face and the part which the muscles of mastication play in its development. He gives new data; the exact measurements made on the growing jaws of his son from infancy to full adult years are valuable; but it is rather to his observations, to his opinions and to his experience, that his work, which was deservedly awarded the Cartwright Prize, owes its chief attraction. Were full justice to be done to his book this review would have to make too serious an inroad on the space available in this journal."

The cause of caries depends chiefly on the lodgeability, fermentability, viscosity, and impermeability of foods with regard to acids and alkalies, while the etiology of irregularities shows that these result chiefly from conditions arising from interference with the natural instinct to gnaw in infancy, and from depriving children, in early life more especially, of those foods which tend to throw pressure strains on the growing jaws. Yet the prevention of both may be co-ordinated, as the proper consistency of food and associated stimulating principles are very useful in preventing caries, while this same consistency of food is similarly satisfactory in supplying the stimulus for pressure strains.

The whole subject when gone into fully is, however, of absorbing interest and the greatest importance, not only from the point of view of health and facial beauty, but also from the light it throws on points associated with developmental anatomy, anthropology, heredity, and several other biogical questions.

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# Chapter XIX

## 1931-1940

## PROGRESS AND CONTROLLED RESEARCH

Passing now to the fourth decade of the present century, we note evidence of considerable progress with regard to the prevention of dental caries, irregularities of the teeth, the deformities of the jaws and their sequelae.

The first communication of outstanding importance published in the *British Dental Journal* in 1931 was entitled, "Some Notes Concerning Dental Caries in South African Children."[1] I shall quote briefly, though the whole article is about twenty pages in length and contains a great deal of material of exceptional importance. Therein it is said:

"Weisman's work established the fact that an injury acquired during life is not hereditary. It may be taken for granted that the teeth are not degenerating; that every child that is born, has in it the capability of making well formed sound teeth, if given the necessary material and the proper means of utilizing this material. Probably, in the vast majority of cases the child does make sound teeth, and the damage occurs after the tooth is formed and erupted. The lack of the necessary material has been called in question many times, particularly the lack of calcium . . . . In Johannesburg we have a very hard water. There is, therefore, no reason to believe that there is a deficiency of calcium. . . .

"The problem of our bad teeth has been attacked from two points of view during the last twenty years: (1) The food we eat as regards its action in the mouth on its way to the stomach. This includes the fermentability of the food, its adhesive qualities and its cleansing qualities. That is, its power of cleansing and polishing the teeth and leaving none of itself behind when the meal is finished.

"(2) The food we eat after it has passed the stomach, been absorbed into the blood-stream and becomes available for the tissues. This includes the supply of raw materials which we have discussed, but more particularly does it refer to the theory advanced by Mrs. Mellanby that our bad teeth are due to a lack of vitamin D.

"The question of vitamin D and how a deficiency of it, affects our teeth has attracted considerable notice. Briefly put, the theory is that certain fats contain this vitamin, that these fats are among the more expensive articles of diet and are, therefore, not received to a requisite amount. Vitamin D has a selective action on the laying down of calcium salts throughout the body. If we deprive the mother during gestation and lactation, or later, the young child, of this vitamin, then bone and tooth formation are deranged and we get rickets and hypoplastic teeth. Further, the theory postulates that, although bone and teeth are similar structures, yet the former is modifiable, while the latter once formed is formed for good, and so a child may have bad teeth and rickets, but if given a sufficiency of vitamin D may reform his defective bone and grow up to be a fine specimen of a man whose only heritage of his early disease is his persistent bad teeth. Briefly this is the theory put forward by Mrs. Mellanby and others to account for the prevalence of caries.

"As we mentioned above, vitamin D is contained chiefly in fats, the oil extracted from fishes' livers having the most. It has been found, however, that vitamin D is also produced by the action of the sun on exposed skin or by the exposure of the substance ergosterol contained in the skin, to the action of ultraviolet light, and that this exposure of the skin to the sun's rays is sufficient to produce the amount of vitamin necessary for the growth of bone and so presumably of teeth. In Johannesburg we are favored with a large amount of sunlight, and, owing to our altitude, the intensity of the ultraviolet rays is greater than at lower altitudes. The actual figures given by Osborn are that, of the actinic rays given off by the sun, provided there are no clouds, 26 per cent reach the earth in England, 43 per cent reach the earth on the high veldt, e.g., Johannesburg. But, in addition, the sun shines only 29 per cent of the total possible in England, as against 73 per cent in Johannesburg. Taken all together, Osburn estimates that if the actinic rays in England are represented by one, we in Johannesburg have ten.

"In Johannesburg and, we believe, in South Africa generally, rickets is practically an unknown disease, due, possibly to the sunlight. According to Mrs Mellanby's theory we ought also to have sound teeth. It is well-known that this is not the case.

"Many people are investigating the causes of caries and its prevention, and we have no doubt that it will soon be just as preventable a disease as, say, enteric fever. Our opinion favors the view that Sim Wallace's theory, i.e., that caries is largely due to the nature of our diet, is correct. In this connection it is interesting and instructive to look into the mouth of a native of forty years of age with a perfect set of teeth and compare it with that of an European of the same age. In the first case, we see the enamel of the teeth on the occlusal surface completely worn off and practically every trace of fissures obliterated. In the latter, the tips of the cusps may be slightly worn down, but the fissures are as they were when the tooth erupted and many of them have fillings in them. If we do come across a European of advanced age with no decay, the wear of his teeth shows a striking resemblance to those of a native."

The first book correlated to our subject in this decade, to which attention must be made, was published in 1931 and is of outstanding importance. It is entitled *The Teeth, the Bony Palate, and the Mandible in Bantu Races in South Africa* by J. C. Middleton Shaw, M.A., B. Dent.Sc., (Dub) Professor of Dental Science; Dean of the Faculty of Dentistry. University of Witwatersrand, South Africa. With a foreword by Sir Arthur Keith.

The special merit of this work is recognized in such reviews as were accorded it at the time of its publication. It links basic facts of anthropology with regard to the teeth and bony palate, and mandible, which are of much greater importance to members of the dental profession who take a scientific interest in biology, than all the laboratory experiments on dogs, monkeys, rats and guinea pigs that have dazzled the medical profession for a quarter of a century.

In this short epitome of the Newer Knowledge of Hygiene in Diet, it must suffice to quote an extract from a review which appeared in *The Dental Record* in September 1931. It reads as follows:

"So scholarly and scientific a paper will always arouse admiration. The present work also awakens interest in no small degree. It is a record of the meticulous and patient investigation of a mass of material; 132 complete skulls, a few incomplete, and over 10,000 Bantu teeth. And it is most conveniently arranged for comparison with the results of other investigators, notably with those obtained by Campbell on Australians, Drennan on bushmen and Black on modern whites. That such a store of information should make such smooth and pleasant reading is an additional virtue, and in this the publishers have assisted with their clearest type and almost lavish spacing. While the whole paper is a feast for the anatomist, as Sir Arthur Keith points out, and for the more learned among dental surgeons, there are many results of a more general interest. . . . In contrast to the relative immunity to caries the Bantu skulls exhibited loss of the supporting tissues of the teeth in over 50 per cent of cases. Absence of the third molars was found to occur with some frequency, but malocclusion was very uncommon. While in Africa, as a whole, tooth extraction (other than therapeutic) is more common than tooth mutilation, this is not the case in South Africa, where the latter only is practiced by a few tribes. The jaws are, generally speaking, better developed in the Bantu than in the modern European, although the actual differences in size are small; the chin is less well defined. The Research Grant Board of the Union of South Africa and the Carnegie Corporation of New York have done well to employ their funds in publishing this valuable investigation, which both in its substance and its presentation may well serve as a model for others."

In the July number of the *Journal of the American Dental Association*, I contributed a paper on The Newer Knowledge of Hygiene in Diet but it is rather long and almost all that is in it may be familiar to the learned readers of *Dental Items of Interest*. However, another communication in the same number of the *Journal of the A.D.A.* by Dr. Weston A. Price, entitled, New Light on the Control of Dental Caries and the Degenerative Diseases, may well be read, since it was apparently not inspired, as was mine, by nineteenth century scientists such as August Weisman who wrote a book on *The Germ-Plasm: A Theory of Heredity*. Weisman, as is well-known, denied that acquired characters were inherited and by implication indicated fairly clearly that there were no degenerative diseases.

To discuss this subject here, however, is not my intention; and there is no special reason to express my opinion on the views submitted by Dr. Weston Price. It may perhaps suffice for present purposes to quote the last question which was put in the short discussion on his communication, R. M. Smith, Iowa Falls, Iowa, said:

"You spoke of cod-liver oil that one gets at drugstores as being very low in vitamin content?"

In reply to this Dr. Price said:

"It is high enough in vitamin D to pass government requirements, but it is not nearly so high as I require for my use. If I had time to use the slides, I could show what serious injurious effects are experienced from giving large doses of cod-liver oil."

Even enthusiastic supporters of the vitamin D theory for the prevention of rickets and dental caries do not regard these diseases as the result of hereditary degeneration. Indeed like Russel Bunting and myself, they are distinctly inclined to regard dental caries as a "luxury disease" and rickets as a disease resulting largely from lack of sunlight, ultraviolet rays and other conditions which were at one time common in the slum districts of large cities.

It is not necessary to pursue this subject further for from the prophylactic point of view it would be far more rational to point out the dangers of a rachitogenic diet and environment than to use as a prophylactic a drug such as irradiated ergosterol, even though it be curative as regards rickets. . . . It should, too, be realized, that a deficiency of what cures is not necessarily the cause of the disease. Perhaps most important of all, it is not wise to initiate or impose a system of prophylaxis depending upon drugs in infancy, childhood, or other age, or advocate any medicine whether it be for the teeth, bones, brain, or anything else. The routine advocacy of drugs in child welfare centers is a most retrograde step. Surely it might by this time be realized that hygiene and public health are, or should be based on biological principles.

In 1932, a highly complimentary communication by A. E. Rowlett (a past president of the British Dental Association), was published on the Prevention of Caries. The following extract from which reads as follows:

"For more than thirty years Sim Wallace drew attention to the dangers of civilized diet to the teeth of the nation and the necessity that each meal should contain certain crisp and fibrillar foods that necessitate vigorous mastication. He is a determined opponent of the great importance that has been ascribed to vitamins in producing immunity to dental caries, a disease which he believes is due to fermentable carbohydrates. He objects to rickets being designed as a deficiency disease, believing rather that an

> alimentary malhygiene, and not a food deficiency, is primarily its cause. His advice to finish each meal with an apple which acts not only mechanically but as an alkaline sialogogue, or with some fresh fruit or salad is everywhere accepted as sound and although his diet has not been afforded the opportunity of test on a wide scale many dentists have used it upon their own children without the use of any other methods of dental hygiene, e.g., toothbrush or dentifrice.
>
> "The food of children, he considers, should be of the chemical composition of milk, but the physical characters of the solid food should diverge from that of milk in proportion to the number of teeth erupted. . . .
>
> "As a pioneer worker in the field of prevention of dental caries Sim Wallace stands in the foremost rank, and his writings upon oral hygiene and prophylaxis have done more probably for the present interest in the problem of the prevention of caries that those of any other individual. The diet which he advocated, as far back as 1904, is extremely interesting when it is remembered that it antedates the discovery of accessory food factors or vitamins by Sir Gowland Hopkins."[2]

Such was the view taken by one of our leading authorities in the dental profession. However, let us take note of the inauspicious work done by the Medical Research Council which also was published in 1932. The book to which I refer was "compiled by a Committee apointed by the Lister Institute and Medical Research Council." It was entitled *Vitamins; A Survey of Present Knowledge.* In addition to this a Committee upon Accessory Food Factors (vitamins) was oppointed by the Medical Research Council jointly with the Lister Institute of Preventive Medicine. The whole book is carefully got up and no doubt meant to be very impressive. There is of course a preface to this work of 332 pages. The first paragraph of this preface may give an idea of what is likely to follow from the same source in future years. Herein we read:

> "In 1919 there was published in this series a Report on the Present State of Knowledge Concerning Accessory Food Factors (vitamins), prepared by the Committee which the Council had appointed jointly with the Lister Institute. The rapid growth of knowledge in this new field of work soon made this monograph obsolete at many points, and a completely new edition, nearly doubled in content, was prepared by the same Committee and published in 1924. That this summary of methods and results was found useful by workers in this and other countries has been well indicated by the numbers sold—10,000 copies of successive impressions have been distributed already. Fresh advances of knowledge soon made complete revision necessary again, and this was undertaken by the Committee in 1930. On this occasion, however, much more complete revision was seen to be required, and the report now presented is an entirely fresh resumption of current knowledge and of technical methods in this subject."

It may well be asked what are we intended to gather from reading this opening paragraph? Is it that each successive generation will require a "much more complete revision?" Perhaps the answer to this would be in the negative; as further on in this same preface we read:

> "It can hardly be contemplated that the rapid and accelerating growth of the subject can be conveniently followed by fresh revisions of such a monograph as this. The labor entailed and the sacrifices of time made by research workers in successive revisions of such a monograph are not likely to be justifiable again."

Having been interested in accessory food factors in relation to the hygiene of the mouth, teeth and alimentary canal since 1900 and having directed attention to the important part played by the physical consistency of food as well as the nature and role of innutritious matter and certain organic acids which act as salivary stimulants, I naturally thought that there would be some reference to those which could quite properly be called accessory food factors. Unfortunately, on consulting the painfully elaborate index, I found nothing about these accessory food factors at all. The word vitamin (a substitute for vitamine) that "struck the imagination of the public" was chosen, even on the title page. This was cunning, but perhaps fortunate, as the origin of the word frequently indicates the basis of ideas built thereon. Let me here refer to a sentence in Huxley's *Lessons in Elementary Physiology* wherein it is noted that:

> "If it is worth while to make a special classification of the vital food-stuffs, at all, it seems desirable to distinguish the *essential* food-stuffs, or proteids, from the *accessory* food-stuffs or fats and carbohydrate—the former alone being, in the nature of things, necessary to life while the latter, however important, are not absolutely necessary."[3]

Now let us refer to the Medical Research Council's ideas of Accessory Food Factors.

A distinct advance was made when the words "Accessory Food Factors" were introduced, but as the late Professor D. F. Fraser-Harris in the *Dalhousie Review on Medical Pioneers in Science* observed:

> "Almost everyone by this time has heard of 'Vitamins.' They were adumbrated by Hopkins in 1912."

Continuing, Fraser-Harris said:

> "This is not the place to retell the story of his discovery of them, but the idea underlying these 'accessory food factors,' which was Hopkins' original name for them, is briefly this. When rats were fed on food sufficient in quantity to make good their wear and tear, and also to supply them with the requisite amount of heat, they did not thrive if that food had been made unnaturally or artificially 'pure.' In other words, on a 'chemically pure' diet these rats did not grow up properly, and they became liable to disease But when Hopkins added a mere trace of fresh milk to their food, the animals began to revive and started to grow again.

> "Sir Frederick called the unknown substances, which even in infinitesimal quantities made such a great difference to the rats, 'accessory food factors.' The meaningless and barbarous word 'vitamin,' for which he was not responsible, is a veritable, verbal, etymological Melchizedek."[4]

Now why was the word vitamine discarded and the word vitamin substituted? Perhaps there is a simple explanation, but first of all let us note that:

> "The real scientific history of the vitamins dates from the time when British eighteenth-century mariners proved that the great plague of seafaring men, scurvy, could be prevented and cured by fresh green vegetables and fruits.[4]
>
> "In 1881, Lunin, in the course of a report upon investigations of the significance of certain inorganic substances in animal nutrition, remarked that since mice can be successfully nourished under laboratory conditions upon milk but not upon purified proteins, fats, carbohydrates, salts and water, it follows that milk must contain other substances indispensable for nutrition. This statement was given wide circulation in Bunge's *Textbook of Physiological and Pathological Chemistry*."[5]
>
> "This epoch-making discovery was apparently unknown to Hopkins, and if known, unappreciated by other European nutritional workers, but was undoubtedly well-known to the Dutch investigator, Pekelharing."[6]
>
> "Pekelharing's experiments consisted of feeding mice on purified proteins, fats, carbohydrates, salts and water, and he found that the mice died on this diet. Whereas, when to the same diet a small quantity of milk was added the mice appeared to live a healthy life. The experiments made by Sir Gowland Hopkins several years later were essentially a corroboration of Pekelharing's and Lunin's experiments.
>
> "To attract public attention, Dr. Funk, in 1912, coined a new term, vitamine, for the substance contained in rice polishings and in the foods that cure polyneuritis in birds and beri-beri in man. Vita is the Latin word for life and amine is the chemical term for nitrogenous which signifies containing nitrogen, a constituent of air and the most significant element of proteins."[6]

Further light is thrown on the word "vitamines," for it would appear that Funk himself said:

> "I must admit that when I chose the name 'vitamine' I was well aware that these substances might later prove not to be of an amine nature. However, it was necessary for me to choose a name that would sound well and serve as a catchword."[7]

Up to the time that Funk introduced this catchword, researches had been conducted which were of great practical value at least where for some reason or another circumstances (generally economic except in the case of scurvy) compelled groups of people to live on foods which were lacking in these substances now called vitamins. It would appear that the catchword produced an infatuation and all the evidence which had previously been brought forward to prove that "infinitely little" of these substances (vitamins) was required was abandoned for the idea that nothing was of much consequence in food except an "abundant" supply of the very things which were shown to be required only in astonishingly small amount. The very fact that the nearest trace of a vitamin in the food or even in less than a tenth part of the food consumed aroused an extraordinary interest in the mystery which at first surrounded them.

Nevertheless, if the experiments are studied, an outstanding fact is revealed—if we put any faith in experiments at all—that in civilized countries, such as England, there is practically no chance of contracting any true deficiency disease if breast feeding is not abandoned.

In the foregoing resumé of the history of vitamins as given by the authorities mentioned, it may be observed that there have been two sets of investigators working on somewhat different lines and with different ideas dominating their researches. One group, in which the names Lind, Takaki, Bijkman and Grijns are noteworthy, directed attention to certain specific diseases which they found could be induced by certain foods artificially prepared, if the dietary was entirely or almost entirely limited to such foods; and further, that by the addition of what had been removed by the artificial preparation of the food, the disease could be prevented or cured. That is to say, a specific effect was produced by the absence of some substance which could be dissolved in water. Funk apparently recognized the similarity of the different diseases under consideration in so far as they were each specifically related to a food deficiency. It might be said that it was the ability to prevent and treat them where they existed that attracted attention.

The other group apparently had no thoughts of specific diseases originating from the absence of specific substances and the experiments indicate that they were specially interested in the growth and general well-being, or the reverse, of their animals, and whether they died or lived and were able to reproduce. As pioneers of this group, the names of Lunin, 1881 and Pekelharing, 1905, may be mentioned. The animals that were experimented on by this group died when the diet was completely or almost completely deprived of some substance or substances which were to be found in milk but it was not recorded that they died of specific diseases such as scurvy or beriberi. Incidentally, it may be mentioned also that the animals fed on those deficiency diets do not appear to have suffered from rickets.

So far back as 1911 when Sir Gowland Hopkins described his experiments:

"The opinion of those who took part in the discussion was almost en tirely in favor of the view that the function of such accessory food factors (as he termed them) must be that of stimulants rather than structural units."[8]

Now let me return to Dr. Aykroyd's observations on Diet and Teeth. On the Preface to the First Edition he says:

"No attempt has been made at comprehensiveness, and the picturesque side of the subject has been emphasized." (1932).

In the Second Edition of Aykroyd's ideas with regard to *Vitamins and Other Dietary Essentials,* we find the statement that:

"Each step towards the establishment of the vitamin D deficiency hypothesis of dental decay has been the signal for violent outbreaks of controversy, which have brightened the sober pages of the *Lancet* and the *British Medical Journal.* The upholders of the old-fashioned theories have poured scorn on these new-fangled notions—the cause of dental decay, they declare, has been fully established for twenty-five years. These acrid controversialists rely mainly on their eloquence, while Mrs. Mellanby and her supporters can appeal to a series of admirably conducted experiments. Granted the truth of the latter theory it is interesting to note how near the 'carbohydrate decomposition' idea came to the truth. Certain carbohydrates do seem to predispose to dental decay, but they do so not because they stick in tooth crevices, but because they have an adverse effect on calcification."[9]

Dr. Aykroyd also evidently referred to my views when he wrote:

"For many years it has been urged that the poor teeth of modern man are due to his unsatisfactory diet. One theory of causation, which is held by many today, may be briefly outlined as follows: Modern civilized man is encouraged to eat over-cooked food—white bread, milk puddings, biscuits, porridge, etc.—in the place of the hard uncooked vegetables and fruit, and the gritty unmilled cereals, which nourish children under more primitive conditions. All teeth contain crevices in which food debris may be sought, and cleansing is necessary to remove them. Now soft food has no cleansing action, but when food is eaten which requires a good deal of crushing and disintegration before swallowing, the tooth crevices are kept clean by friction. Further, soft foods such as bread soaked in milk and porridge, are largely composed of carbohydrates, which, when held in the tooth crevices, become decomposed by the action of bacteria. The result is the formation of organic acids which eat away the dental enamel and give rise to caries. It seems quite a pretty piece of reasoning. On the other hand, the theory, now ineradicably fixed in the public mind, that dental decay is caused by excessive consumption of sugar, rests on no reasonable basis whatever Sugar is a carbohydrate, it is true, but it is dissolved by saliva and does not linger in the mouth to provide food for bacteria. It appears that the West Indian natives, who eat very largely of sugar cane, have very good teeth indeed."[10]

Dr. Aykroyd then gives two lists, one of foods likely to prevent dental decay, the other of foods tending to produce it. This was no doubt taken from my book on the *Prevention of Dental Caries*, the first edition of which was published in 1911 in the Appendix. The words he used were the same as those of mine but he gave no reference to where or when they were published.

Here, however, let me repeat the lists given by me in 1911 and reproduced practically word for word by Dr. Aykroyd.

### Liable to Induce Dental Caries

Farinaceous and sugary food in general without fibrous element.

*Examples:* Sweet biscuits and cake; bread and marmalade; bread and jam; new bread without crust; bread soaked in milk; milk puddings; porridge and milk; stewed fruit; chocolate and sweets of all kinds; honey.

*Liquids:* Cocoa and chocolate.

The above foods should not be eaten except when followed by foods of the cleansing type.

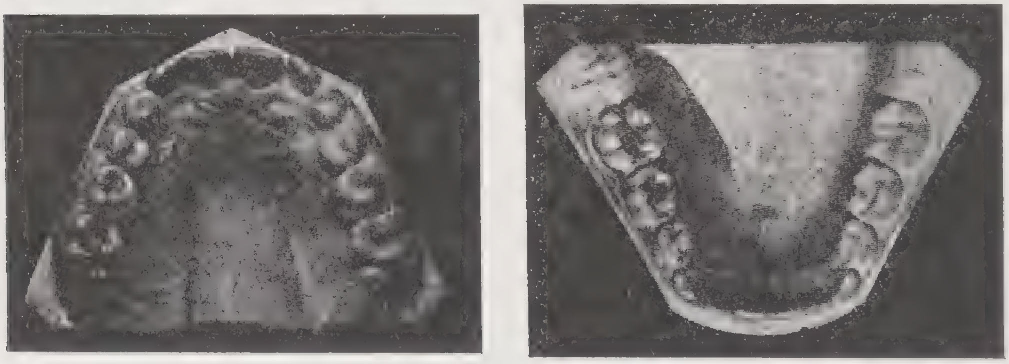

Fig. 1

Fig. 2

Figs. 1 and 2. Photographic reproductions of two typical models.

### Cleansing and Preventive of Dental Caries

Fibrous foods generally.

*Examples:* Fish, meat, bacon, poultry. Uncooked vegetables, lettuce, cress, radish, celery. Cooked vegetables are as a rule cleansing, but in a less degree than uncooked vegetables.

Stale bread with crust; toasted bread of all kinds; twice baked bread; pulled bread and cheese. Savouries. Fresh fruits, especially those requiring mastication, e.g., apples. Fatty foods, e.g., butter and margarine. Liquids: Tea, coffee, water, also soups and beef tea.

Now why should Dr. Aykroyd have given these lists which were given in the Appendix at the end of my book on *The Prevention of Dental Caries* and omitted any reference with regard to the photographic reproduction (Figs. 1 and 2) of two "typical models of child's mouth, aged 10, brought up in accordance with the principles advocated, without resort to any artificial aids to keep the teeth and gums clean, healthy, and free from any trace of caries."?

The right side (the left on this page) of each model was dipped into carmine, let dry, then brushed. This was repeated twice. The photographs indicate how imperfectly the crevices and interdental spaces of teeth are cleaned. Incidentally it may be noted that the models show a particularly perfect set of teeth without crowding and consequently relatively easy to clean. The child, one of the fourteen already referred to, having been brought up on food requiring mastication, has worn the cusps, especially of the temporary teeth, so that the crevices are relatively easily brushed.

Had he done so he would surely have recognized that although physiological mouth hygiene is of paramount importance, I never implied that: "as long as children diligently ply the toothbrush two or three times a day their teeth should remain white and undecayed."[11] I have indeed frequently claimed that we cannot rely on the toothbrush even with antiseptic mouth washes for the prevention of dental caries.

The following rules were given in a communication which I read at the Guildhall Conference on School-Children Diet, May 13th, 1912, regarding Reform in Feeding at Schools.

Certain rules naturally follow a recognition of the fact that some foods tend to leave the mouth dirty, while others tend to clean the mouth and teeth. The following are the more important, at least with regard to children of school age.

1. Children should always have a considerable amount of the farinaceous food in a form which will stimulate a pleasurable amount of efficient mastication, and thus promote the normal growth of the jaws and a regular arrangement of the teeth. The albuminous part of their diet should be presented in a form which will encourage mastication—e.g., boiled fish, meat, and bacon.

2. The meals should be arranged in such a way that if soft, starchy, or sugary food, has been eaten, the mouth and teeth will be cleansed by food of a detergent nature taken immediately after. Thus, therefore, when sweets of any kind—e.g., milk-puddings, jam rolls, cake, sweet biscuits, bread and marmalade or jam—are eaten, fresh fruit should be eaten afterwards.

3. Three meals daily are to be preferred to any greater number, as the longer the interval the more hygienic is the state of the mouth and stomach

and more perfectly prepared for the reception of a further meal. Sweets, chocolate, or biscuit and milk should never be eaten between meals or before going to bed.

When these rules for the prevention of decay in teeth cannot be observed, some attempt should be made, with a small toothbrush, to clean the crevices of and between the teeth after every unhygienic meal; but as this is extremely difficult to do effectually without injuring the teeth or gums, it is advisable to have children, who are brought up in this way, taken regularly to the dentist from the age of three onwards every six months, till the teeth become crowded and irregular; thereafter the visits may require at times to be more frequent until all the natural teeth have been replaced by artificial substitutes.

We may here take special note of what Henry Sewill* said in the Second Edition of his well known manual where he refers to the *Relative Frequency of Caries in Different Classes of Teeth* (p. 158).

> "It is a remarkable fact . . . . that teeth are not all equally liable to be affected by caries. Series of cases have been tabulated from time to time by various observers, and these agree in the main with each other. The following statistics of 10,000 cases collected by Magitot show the relative frequency of caries of the different kinds of permanent teeth."[12]

The following statistics of 10,000 cases collected by Magitot show the relative frequency of caries in the different kinds of permanent teeth.

| | | | |
|---|---|---|---|
| Central incisors | 642 | Superior<br>Inferior | 612<br>30 |
| Lateral incisors | 777 | Superior<br>Inferior | 747<br>20 |
| Canines | 515 | Superior<br>Inferior | 445<br>70 |
| First bicuspids | 1310 | Superior<br>Inferior | 940<br>370 |
| Second bicuspids | 1310 | Superior<br>Inferior | 810<br>500 |
| First molars | 3350 | Superior<br>Inferior | 1540<br>1810 |
| Second molars | 1736 | Superior<br>Inferior | 690<br>1046 |
| Third molars | 360 | Superior<br>Inferior | 220<br>140 |
| | 10,000 | | 10,000 |

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*Past President of the Odontological Society of Great Britain.

The first point which attracts attention in these tables is the great relative frequency of caries in the first molars; the next the much greater frequency of the disease in the front teeth of the upper than in those of the lower jaw. It must, however, be admitted that no entirely satisfactory explanation of the ratio of frequency in the several classes of teeth has yet been afforded. Sewill's book was published ten years before the first edition of my book on *The Prevention of Dental Caries* appeared, and consequently long before the photographs of the models showing where and why caries is most liable to occur. As indicated:

The accompanying photographs show perfectly clearly why caries begins and progresses where non-detergent foods are most liable to lodge, as has already been noted in the footnote of the photographs depicted of the models of a typical child's mouth when he was ten years old.

Now consider the incidence of caries as to the relative frequency of caries in the different classes of teeth and particularly the influence of vitamin D with regard to the structure of enamel and dentin of teeth, whether they belong to the temporary or permanent dentures. Then note that "molar teeth, though even less calcified than the incisors are much more frequently attacked by caries than the latter."[13]

I have given considerable space to what Dr. Aykroyd has said on the subject because he assisted the Committee which prepared the Report on "*Vitamin: A Survey of Present Knowledge*" which was published in 1932, and no doubt gave special assistance to what was said in Chapter IV on *Vitamins and Dental Tissues.* Judging from what Aykroyd wrote in his books on *Vitamins and Other Dietary Essentials*,[14] he presumably assisted in bringing to light the history of "The Discovery of Vitamins," for in the chapter of his book relating to this subject he referred to Sir Gowland Hopkins "Feeding Experiments" illustrating what happened in rats when they "were fed on a mixture of milk-protein, starch, sugar, and lard containing protein, fat and carbohydrates in correct proportions and adequate amounts, they remained alive and grew a little—as long as the substances were fed in a crude state. When the food mixture was purified, the animals died. Hopkins thereupon added a little milk, 2-3 cc., to the purified diet, an amount too small to contain appreciable additions of protein and fat, and found that on the milk-supplemented regime his animals thrived. The growth curves of the famous Hopkins rats are familiar to anyone who has ever opened a textbook of physiology. . . . It was the prettiest experiment imaginable."

"Feeding experiments illustrating the importance of accessory factors in normal dietaries, *Jour. Physiology*, 1912, XLIV, 425, ranks esthetically beside the best short stories of H. G. Wells."[15]

Let us examine the subject more closely. It will be admitted that milk contains all the substances necessary for growth and life in young rats and suckling babies. Moreover directly or indirectly milk stimulates evacuation of such substances as are not wanted, e.g., the residues of the cells of the mucous membrane which have performed their function of absorbing what is necessary for the needs of the body. These cells require frequent renewal in infancy more especially. Milk is also a substance upon which bacteria can proliferate. No doubt in conjunction with other attributes, it tends to stimulate the phagocytes which control or destroy such bacteria as might be harmful to the infant. Thus the conditions of the cages in which rats are kept or in which infants live must be maintained as hygienic as possible. On the chapter on vitamin D, Dr. Aykroyd referred to experiments which indicated that "when the cages in which rats were kept were exposed, empty of their occupants, to the light of the quartz lamp for ten minutes daily, comparatively normal calcification occurred in the animals in spite of a diet deficient in fat-soluble vitamins. It was as though the very air in the cage had been changed in some subtle way. . . . Most foods treated in this manner become strongly antirachitic," even though before irradiation they are devoid of vitamin D, or rather might we say before irradiation had destroyed harmful bacteria. "In Hume's experiments it was not the air in the cage that had undergone alteration, but the sawdust at the bottom which the rats subsequently devoured."[16]

This leads to the possibility of another error. Milk when drawn from the breast by an infant contains sugar of milk, i.e., "lactose, $C_{12}H_{22}O_{11}$ + $H_{20}$, occurring as a gritty powder of moderately sweetish taste."[17] This may certainly act as a detergent foodstuff. It would appear that milk sugar, i.e., which is found ordinarily only in milk, stimulates the mucous glands, the glands of alimentary hygiene—for when an animal is starved of this so-called vitamin "the mucous glands atrophy,[18] so that the alimentary canal gets into an unhealthy state. In a normal animal the intestinal bacteria are restricted to the central lumen of the intestine," but when the absence of lactose deranges the alimentary canal, "the intestinal bacteria penetrate between the villi into the crypts of Lieberkühn and into the mucous glands of the caecum which they fill and where they proliferate."[19]

Further we may ask why *cane* sugar was given as the purified carbohydrate in Sir Gowland Hopkins experiments? It has not the same formula as lactose, nor does it contain a gritty powder of moderately sweetish taste. The formula given for glucose or cane sugar does not add + $H_2O$ as does the formula given for lactose.[20]

Then again there are "lymphcells (leukocytes, which have received the suitable name of phagocytes), present in great numbers in the connective tissue of the mucous membrane. These cells, which are capable of the most complete amoeboid movements, become migratory, force their way through the epithelium of the gut and come into contact with the food in the lumen of the intestine. Others of these phagocytes again, seem to take up the nutritious particles only after the latter have penetrated through the epithelium into the connective tissue layer. The phagocytes possess the further peculiarity of taking up noxious substances or portions of tissues which have undergone retrogressive metamorphosis, wherever they occur in the body, thus rendering them innocuous. Thus they exercise a kind of superintendence over the body, acting as a sort of police force."[21]

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# Chapter XX

## VITAMINS (FOURTH DECADE CONTINUED)

Now what did all this elaborate book entitled *Vitamins: A Survey of Present Knowledge* amount to? Take for example what Dr. Akyroyd said in the second last paragraph of his chapter "Diet and Teeth," in his manual entitled *Vitamins and Other Dietary Essentials.* (2nd Edition 1936).

Here he admits the fact that "This account of dental caries has been written with a bias in the direction of one particular theory of causation, and it is wiser to close the chapter on a note of interrogation. . . Certain facts are difficult to fit in. It appears that rachitic children, in spite of their malformed teeth, are not always more prone to dental caries than non-rachitic children. . . The old carbohydrate decomposition theory may contain some germ of truth."[1] Why should he not have noted that there might have been, indeed that there was an error in the experiments associated with the "Feeding Experiments" on rats already referred to.

To make my contention more explicit let it be noted that cane sugar gives rise not only to a fermentation resulting in the formation of lactic acid, but also to a minnitic fermentation. Schutzenberger gives the following equation which will explain what takes place:

$$\underset{\text{Cane sugar}}{25(C_{12}H_{22}O_{11})} + \underset{\text{Water}}{25(H_2O)} = \underset{\text{Gum}}{12(C_{12}H_{20}O_{10})}^{2}$$

$$\underset{\text{Mannite}}{24(C_6H_{14}O_6)} + \underset{\text{Carbon Dioxide}}{12(CO_2)} + \underset{\text{Water.}}{12(H_2O)}^{22\quad 3}$$

Following this quotation from Schutzenberger's book, I said: "No doubt this viscous gum acts as a very effective barrier to the beneficient influence of the saliva, and as this fermentation takes place along with lactic acid and other fermentations, and the deposited gum acts as a food-catcher, retainer, and acid fermentation protector, we need scarcely wonder that there is a popular impression that sweets are bad for the teeth. . ."[2]

Now we may return to our chronological sequence in the fourth decade of the present century. In the *Journal of the American Dental Association* for August 1933, there appeared a rather unique yet significant communication entitled "Normal Development of Teeth Associated with Enforced

Dietary Restrictions as the Result of Congenital Stricture of the Esophagus"[4] which enforces the value of a milk diet.

In their communication we read: "A well balanced diet and the inclusion in the diet of foods that bring into use the forces of mastication have been stressed as essential factors in the normal development of teeth. Although it is not the purpose of this report to minimize the desirability of these factors, we wish to call attention to the fact that an individual may develop normally in every way on a diet consisting largely of milk.

"*Report of Case.* A man, aged twenty-three, came to the Mayo Clinic for examination, March 10, 1930, complaining of difficulty in swallowing that had been present since birth. Until the age of sixteen years, his diet consisted almost entirely of milk with the addition of cocoa and cream of wheat made into a thin gruel . . ."[5] This was accompanied with observations and photographs of the patient's appearance "showing good state of nutrition and of the teeth although the patient's diet had been deficient" (Fig. 1). Figure 2 gave dental roentgenograms, "showing that there was 'no evidence of caries.' " Figure 3 was the photograph taken from "Snap modeling compound impression" in which the teeth gave "no evidence of wear." What is not mentioned though evident from the photographs was that the patient recorded by Austin and Vincent revealed the fact that "the teeth show just that type of general crowding which we so frequently see at the present day. A comparison of the photographs of the jaws and teeth with measurements[6] of a young man (of similar age to that of the Vincent patient) who was deliberately brought up on a diet demanding mastication should convince anyone that the photographs by Austin and Vincent were far from satisfactory as regards jaw growth and freedom from crowding of the teeth." "And moreover if the measurements and photographs of the teeth and jaws recorded by Drs. Austin and Vincent in the patient of twenty-three years of age are examined carefully it will be noted that the third permanent molar had been so crowded out, or rather retarded in its eruption, that it does not appear at all in the photographs on one side both above and below. Whereas in the photographs of the young man recorded by me even at the age of 19[7] the wisdom teeth were all erupted fully and there were no signs of crowding. The photographs of the occlusion both lingually and buccally at the age of twenty-four showed perfect occlusion."[8]

Let it be noted, however, that in 1900 I said: "Milk which is often a prominent part of young peoples' diet may indeed be harmless when consumed alone"[9] with regard to dental caries; and I still recognize this fact.

The next book to which reference may be made is entitled *A Short History of Dentistry*, (published in 1933). It was written by Lilian Lindsay presumably because the General Editors of the "Short History Series" thought she was most ably suited for the work. In addition to having been an L. D. S. Edinburgh, for many years, she now can append the following honorary distinction and degrees to her name. C.B.E., L.L.D., Edinburgh and M.D.S., Dunclm. H.D.D., Edinburgh, and finally F.D.S.R.C.S., England.

On looking over the index of her book we note the names of Aristole, G. V. Black, Galen, John Hunter, Leeunwenhoek, John Tomes and various other names that still live in the history of dentistry. Although sugar is mentioned three times in the index it gives but little information with regard to any scientific record as to why sugar and sweetmeats lead to the destruction of the teeth. Dealing with the prevention of dental disease, however, Dr. Lilian Lindsay goes into the recent history of the subject briefly, simply and accurately. She noted that: "At the International Medical Congress in 1881, Arthur Underwood and W. J. Miles communicated the result of their investigations into the 'effects of organisms upon the teeth and alveolar portions of the jaws'; this was the first bacteriological attempt to discover the bacillus of dental caries. W. D. Miller, of Berlin, extended and confirmed these researches and published, in 1884, his theory which has since been known as the chemico-parisitic theory of dental caries. In 1839, William Robertson, of Birmingham, suggested that sticky food remaining upon the occlusal and interstitial surfaces produced decay at these places, and Magitot, in Paris, had given a thesis on dental caries in 1867 in which he investigated the effect not only of food but also of saliva on this condition. For centuries it had been held popularly and in the writings of dentists that sugar and sweetmeats destroy the teeth."

Now why did the Medical Research Council make no reference to the history of the Prevention of Dental Caries? Perhaps this can be accounted for by the great British maxim "To ignore is to destroy." But one, two or many can play at this game. Dr. Lilian Lindsay did, although she was quite well aware of the volume of literature relating to vitamins and caries in man, in dogs and other animals. Some of us, however, like a full discussion on subjects which are of great importance to humanity. So perhaps it may be well to refer to two books by specially well qualified authorities which were published in 1935 and 1936. The titles of the books to which I refer were (1) *Studies in the Actiology of Dental Caries* by G. Graham Macphee, M.A., Md., Ch.B., L.D.S. and (2) *What Is Wrong with British Diet?* 1936, by Harry Campbell, M.D., Fellow of the Royal Anthropological Institution. (He did not put the letters F.R.C.P. after his name in this book although he was quite entitled to do so). Let me now give references taken from Dr. Macphee's and Dr. Campbell's books.

Quoting from the chapter on Diet and Nutrition in Macphee's important book we read that: "Hitherto the experimental evidence offered by Mellanby and her co-workers was accepted without question, but in 1932 McCulloch[10] reviewed the most important investigations at that time and showed that not only were the conclusions drawn from the experiments unjustified, but the experiments themselves were fallacious.[11]

"He pointed out that in dietetic work 'the first essential in testing the effects of any food material is to have dietaries which are strictly comparable and *adequate in all respects* except the one under review.' In much of Mellanby's work he did not find any of these postulates fulfilled. He stated that 'the dietary was woefully deficient in every particular' for puppies, as 'the essentially carnivorous dog is forced in this experimental work to obtain 50 per cent of the energy requirements from cereals which contain the essential salts of calcification in a ratio very different from that required in the ideal dietary, and considered the Mellanby dietary as an ideal high phosphorus, low calcium rachitogentic one without any necessity to postulate a harmful substance in the cereals.' . . .

. . . "Although McCulloch's criticisms appeared well over two years ago, no satisfactory reply appears to have been published by Mrs. Mellanby or her co-workers.[12]

"The production of vitamin D by the action of ultra-violet radiation . . . lead us to suppose that children living in a sunny country should have better teeth than British children, if vitamin D really is as important in relation to dental caries as its advocates claim. In England, according to Shaw (1932),[13] the total annual insolation is less than half that at Johannesburg, where the actinic rays of the sun are more powerful than in England. . . Yet he found just as great an incidence of dental caries in 600 school children in Johannesburg as in England."

Continuing Macphee says "In my experience, one patient disproves the whole vitamin D theory. This patient, a boy, aged fourteen, in 1933, whose father is a scientist, has been brought up for the last ten years on cod-liver oil in abundance, milk, orange juice, and all these things which ought to produce good teeth, including, more recently synthetic vitamin D. While his temporary teeth were moderately good, his permanent dentition shows rampant caries of the rapid type. Although it is easy to say this single case is an exceptional one, it is difficult to explain satisfactorily to the intelligent parent why the vitamin D therapy and other measures have failed so completely."[14]

Now let me give a few quotations from the late Dr. Harry Campbell's book, entitled *What Is Wrong with British Diet?* (1936).

In the introduction to his book he notes that "A perfect human diet is one calculated, given adequate bodily exercise and abundance of out-door life, to bring about normal nutrition and growth. Such a diet implies (A) that it shall contain duly proportioned essential nutrient ingredients—proteins, carbohydrates, minerals, and vitamins. But this is not all: a perfect diet requires (B) that it shall (1) afford adequate exercise for the jaws and teeth, and that it shall (2) tend to leave the mouth clean. (A) As regards nutritive value, British diet errs mainly in containing excess of cereals and starchy food generally, and a dearth of animal and raw vegetable foods. Sugar also, especially among the young, is apt to be in excess. . . (B) We have seen that normal human diet requires not only to be nutritionally efficient, but (1) that it shall ensure adequate exercise of the jaws, and (2) that it shall tend to promote mouth cleanliness. In both these respects the customary diet of the British people fails lamentably. Hence our small jaws and shocking teeth[15] . . . The failure to appreciate the supreme importance of oral hygiene as a preventive of dental decay arises from ignorance of what oral hygiene implies (see Part III, Chapter XIX)."[16]

The reader may observe that I have omitted over 200 pages of the late Dr. Harry Campbell's book. This is not intended to indicate that the omitted pages are not as full of interesting and instructive information as the short quotations I have given. Quite the contrary. Indeed it is difficult to refrain from referring to Dr. Campbell's observations with regard to the history of vitamins. He mentions that in 1905, C. A. Pekelharm

made the *first great advance*: "He found that mice fed on bread baked in casein, albumin, rice flour, lard, and the needful salts died from starvation in four weeks, while *the addition of a small quantity of milk rendered the diet..adequate."*

He concluded: "There is an unknown substance in milk which even in small quantities is of paramount importance in nutrition."[17] . . . "About 1906 Gowland Hopkins carried on important investigations (published in 1912). The synthetic (basal) diet employed by him consisted of protein, carbohydrate, lard and the necessary salts. This proved to be a starvation diet for growing rats. The daily addition of 2 cc. of milk, however, rendered the diet adequate. Here again, *the milk contained the unknown essential.*"[18]

Surely it is now quite well known that milk sugar lactose is contained in milk, and is a carbohydrate essentially different from cane sugar both in taste, physical consistency and solubility. More than that, milk is a complete food for young mammals not only from the point of view of nutrition but also presumably from specific diseases which confer a certain immunity to many diseases from which children are liable to suffer.

It certainly should be recognized that purified saccharose can never be regarded as a purified carbohydrate with the same attributes as lactose when we are dealing with diet from the point of view of alimentary hygiene in mammals. Now let us take note of what these experiments on animals have lead to, more especially with regard to the teeth.

I am quite well aware that a presumably authoritative book was published in 1937 which contained the two following sentences. "Dental caries occurs when the diet is deficient in vitamin D especially when this is associated with excess of cereals or deficiency in calcium. It is now known that the organic acids produced by carbohydrate food has nothing to do with its developments."[19]

Dogmatic statements such as the foregoing have been made by some medical men with as little appreciation of the newer knowledge of hygiene in diet as I myself had, after having become legally qualified to practice medicine and surgery nearly sixty years ago.

About that time (1890), it was quite generally supposed that the chief function of the saliva was to digest starch, but on reading *Huxley's Lessons in Elementary Physiology,* a year or two after an enlarged and revised edition was published in 1900, I found that although saliva contains "a small quantity of a peculiar substance called ptyalin, which has certain very remarkable properties . . . its importance must not be over-estimated" (p. 240). Some thirty years later, wanting to learn whether any advance had been made, I read D. D. Rosewarn's book on *The Science of Nutrition Simplified* and was pleased to find it said that: "Mastication, although not a part of digestion proper, is a very important preliminary" (p. 53) and in page 55 of this book there is a note stating that: "The saliva contains feeble quantities of ptyalin, an enzyme which converts starch into sugar, and it has been claimed that this ferment effects a preliminary digestion of starch in the mouth, which continues in the stomach. Very little importance is now attached to this view."[20]

In America, experiments with large groups of children have been carried out by R. W. Bunting and his collaborators. They state that "by experimental feeding of a well balanced diet from which sugar and candy were practically eliminated, to a large group of children over a period of one year, it was found that they developed normally and were in good health, and that the growth of *B. acidophilus* in the mouth and dental caries were markedly reduced."[21] Later in his summary of the "Bacteriological Chemical and Nutritional Studies of Dental Caries by the Michigan Research Group" Bunting does not indicate that milk is a protective food as far as caries is concerned, or that vitamin D, calcium or phosphorus in an ordinary diet requires to be supplemented by any special supplies of these ingredients. Perhaps it would be best to give his own words:

"1. No consistent correlation could be found between amounts of salivary total solids, ash, Ca, P, Cl, diastatic activity, pH, $CO_2$-capacity, or total alkalinity, and activity of dental caries. 2. No relationship could be found between intake of Ca, P, and vitamin D, or acid base dietary values, and activity of dental caries. 3. Evidence is submitted indicating that sugar is a very important consideration in dental caries. 4. A remarkable low degree of dental caries was observed in children on a low sugar diet deficient in Ca, P, and vitamin D."[22]

It was with regard to the prevention of the irregularity of the teeth that I especially drew attention to the uselessness of milk. It was to stimulate the healthy growth of the jaws that I advocated food which resembled milk from the point of view of nutrition, but which should differ from milk in its physical characters in accord with the physiologic requirements of the teeth which the child has at a particular time.[23] The full development of the jaw generally demands muscular activity and liberating stimuli to this end. The teeth are formed independently of functional activity, so that they attain their normal size even though the jaws are abnormally small, and thus irregularity is certain to result. Can we ignore the value of solid foods which stimulate mastication and omit them without due consideration of the effect? Can we consider a dietary "balanced" or "adequate" which does not contain a proper proportion of unabsorbable matter, such as cellulose?

The report of the Medical Research Committee on "The Present State of Knowledge Concerning Accessory Food Factors (Vitamins)" says,

> "It is difficult to implant the idea of disease as due to deficiency. Disease is so generally associated with positive agents—the parasite, the toxin, the materies morbi—that the thought of the pathologist turns naturally to such positive associations and seems to believe with difficulty in causation fixed by a minus sign."[24]

It might be said that it is all too easy to implant the idea of disease as being due to a deficiency. Nothing is easier than to get ailing people or even pathologists to believe that they are not getting enough of this, that or the other thing, and that many of their troubles are due to not getting what they want. Certain pathologists, who were not fully conversant with ideas emanating from the dental profession, imagined that dental caries might be a deficiency disease, though it had been perfectly well-known, since 1890,[25] that caries was due to a positive and active condition external to the tooth and resulting from bacterial fermentation of carbohydrates under certain conditions. It should have been observed that although the prevalence of caries was to a large extent due to the deficiency or elimination of certain qualities of the food which tend to keep the mouth, teeth and alimentary canal in a hygienic state, the positive cause of these diseases was well-known to be microbic.

To illustrate more clearly my meaning and to indicate how easily confusion may arise, let me refer to the cause of the prevalence of dental caries as put forward in 1900, and the positive, "actual" or "immediate" cause of caries which had previously been well elucidated and established by Miller and others. In my first book, which as the title indicates was *An*

*Investigation Into the Cause of the Prevalence of Dental Caries*, it was noted that "it was not so much any particular foodstuffs which seemed to induce caries as the elimination of the fibrous part and its destruction by most methods of cookery." This statement, taken apart from the general thesis of the book, may have caused some confusion in the minds of those who did not know that the direct or "immediate" cause of caries was quite well known long before 1900, and that consequently it was largely to explain the cause of the prevalence of the disease and how it could be prevented that the book was written. Not only was it contended that the foodstuffs, being deprived of their stimulating components, were liable to lodge and undergo acid fermentation in the mouth, but it was also noted that "from the same cause and induced conditions the micro-organisms of the mouth lodge and multiply and augment the rapidity and intensity of the acid fermentation."[26]

A little later[27] (1904), I indicated the kind of bacteria which the carbohydrates specially induced to proliferate by inserting the words "acid producing" before the words "micro-organisms."

Among many who were but little acquainted with the significance of accessory food factors of a detergent or hygienic nature, there arose the notion that certain foods, from the point of view of nutrition, were protective against certain diseases, and the protection was attributed to vitamins. The idea that certain diseases could be prevented by eating certain foods was shown to be true long before the ideas associated with vitamins arose. Particularly was this so with regard to scurvy and the diseases of the teeth. When the vitamins began to attract attention, many saw that there was some similarity in the foods previously claimed to be preventive of dental caries from the point of view of oral hygiene and those which contained vitamins, more particularly vitamin C. It soon became known that this vitamin was generally present in fresh fruit and vegetables, and almost immediately the vitamin enthusiasts who did not know about the detergent effect of these foods on the teeth imagined that the excellent results in the prevention of caries which had been recorded when these foods were regularly included in the dietary were due to this vitamin.

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# Chapter XXI

## CIVILIZATION AND THE PREVALENCE OF DENTAL CARIES — FOURTH DECADE

Before proceeding further with regard to vitamins and the diseases of the teeth, it may be well to make a brief resumé of our knowledge for more than a hundred years before the first decade of the present century. One of the most notable facts that came to light during this time was that notwithstanding the progress of civilization together with advances in the practice of medicine and sanitation, dental caries, abnormalities in the jaws and other diseases associated therewith had become more prevalent. Indeed it was not until the end of the first decade of the present century that a change for the better had commenced to take place, at least with regard to dental caries.

Not so very long ago I wrote an article in *The Medical World** on "Civilization and the Prevalence of Dental Caries" referring to the subject and here need only give a few extracts therefrom. It commenced as follows: "It is more than a century since L. S. Parmly quoted Joseph Fox, another celebrated dentist, as having said 'The great distress which usually accompanies, and the inconvenience which always follows the loss of the teeth, make the *discovery of some mode of prevention of caries very desirable.*' "[1] During the last fifty years the urgency of the discovery has become overwhelming from the above and other reasons. I have referred at some length to Parmly's work in an earlier communication,[2] and would here only draw attention to a correlated problem.

As is well known, the problem specially occupying the attention of dentists, physicians and some few scientists is the cause of the *prevalence* of the disease. To indicate this more fully let me quote from a recent article by Professor Humphrey F. Humphreys, in which he naturally dwells on "The enormous increase in the incidence of the disease in modern times, particularly in the last century, amongst the white races. Though an ancient disease, its incidence stamps it as a disease of civilization and one might almost say a disease associated with improved nutrition. Amongst ancient Egyptians it was almost confined to the wealthy classes and in modern times it increases pari passu with the successive rises in the standard of living; so that on historical grounds it would appear unlikely to be a deficiency disease, though the case of beriberi shows that this is not impossible. But reflect on the evidence we possess from the social life of the poorer classes in the Middle Ages, a period when dental caries appears to have been uncommon; throughout the winter months they had no fresh meat, no vegetables or fruit, and little, if any, milk, and in England lived almost entirely on cereals, salted meat and bacon. This is a diet which anyone today would regard as neither balanced nor adequate, and which must have been considerably deficient in vitamins, yet it did not give rise to dental caries. Clearly in accounting for its modern prevalence we have to isolate some factors which operate today but which did not operate some centuries ago. This is our problem."[3] and it rules out what even up to the end of last century were regarded as the most important problems to solve. At that time, indeed, the question of susceptibility and immunity to the disease, and the theory that it was biologically hereditary, were the two great problems which the leaders of dental thought were struggling to elucidate. In 1895, however, G. V. Black,[4] possibly inspired by the work of William Robertson,[5] made an investigation into the chemical and physical characters of the teeth, and showed that the idea of deficient calcification as an explanation of the cause of the prevalence of caries was quite untenable. Black's investigation was corroborated in England by Sir Chas. Tomes in 1896,[6] but nevertheless Black still believed in the hereditary nature of the disease, so much so that he supposed "the hereditary predisposition of certain families to caries has been so generally observed that it will not be questioned."[7]

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*The Medical World, July 22nd, 1938.

Two observations may be made on this. The first is that the theory of the hereditary nature of the disease is no more true than is the theory of the hereditary degeneracy of the teeth, and here it may be said that Leon Williams and others failed to find any evidence of such supposed degeneracy. Black's theory, like that of Parmly and of William Robertson, claimed that the cause of caries was invariably, in its initial stages, external to the tooth. He did, indeed, believe in the chemico-parasitical theory which was brought into a dominating position by W. D. Miller some ten years before. Holding these ideas, but confirmed in the belief of its hereditary nature, Black and his successors turned to an investigation of the saliva for an explanation. A great deal of investigation has been made on this subject but without any very profitable result, and it may be said that no consistent theory with regard to the nature of the saliva has been brought forward which indicates that there has been any change in the quality of the saliva any more than there has been any change from an hereditary point of view in the enamel.

Not until the very end of the 19th century, when I wrote my first book,[8] had anyone observed that the theory of the hereditary nature of caries (in the biological sense) was quite erroneous. The explanation of the fact that caries ran in different families and in different races of mankind was shown[9] to be not a biological inheritance, but what has recently been called a "legal inheritance"; the customs, traditions and dietetic habits being passed from one generation to the succeeding generation just as is property. Let me here quote the words of a reliable modern scientist with regard to this subject. He says: "It has taken scientists a long while to outgrow the confusion between legal inheritance and biological inheritance. When Darwin wrote the *Origin of Species* the phenomena of fertilization had not been fully elucidated. Biologists still believed that people hand on their noses to their offspring in much the same way as they hand on their bank balances. Weismann performed a great service to biology by pointing out that the state of death claims all our accumulated anatomical earnings."[10] Considering the foregoing, we were, and still are, well justified in believing that except as dietetic stimulants, investigations into variations of and the quality of the saliva are of no value in the explanation of the increased prevalence of the disease. Even to the present day, however, the theory of the quality of the saliva accounting for the prevalence of caries is still brought forward. And built upon this untenable assumption we have had contentions that the nature of the acid-producing bacteria which initiate caries are dependent for their presence on the hereditary nature of the saliva. The quality of the saliva in its turn being supposed to be the result of some quality of the blood (which would apparently require to be of a hereditary nature) has been advanced, but not by any means generally accepted. I fancy that the proposed method of conferring immunity by injections to immunize individuals against caries will be abandoned like theories of "adequate" and "balanced diet," or therapeutic agents, which it has been contended would destroy the acid-producing bacteria, while leaving the harmless micro-organisms to proliferate. The whole theory of prevention based on these suppositions is just as impracticable as would be the application of eugencies to save future generations from dental caries. That the essentially local nature of the disease resulting from conditions external to the tooth should be questioned would seem strange were it not that the principles of biology are forgotten and the teaching of the physiological processes which should keep the mouth and alimentary canal in a hygienic state almost completely neglected so far as dental and medical students are concerned.

Fortunately, when we make a general survey of dental literature during the present century we note many salutary changes. Thus the hereditary degeneracy theory of the cause of caries is now but rarely seen. A description of the real process of mastication and the physiological processes which keep the mouth in a hygienic state have been presented to dental students since 1910,[11] and the latter have also been referred to by eminent physiologists.[12] Among physicians the most distinguished and well-informed exponent of the newer knowledge was the late Dr. Harry Campbell, whose contributions to medical literature for many years and recent book on *What is Wrong with British Diet?*[13] have done much to enlighten the medical profession. Among pediatricians, Dr. Leonard Findlay and Dr. John Thomson have been the most prominent in the support of the views of the new school.

It is noteworthy that the appreciation of the hygienic nature of foods such as apples, fresh fruit and salads, is now almost universally insisted upon and excellently explained and enlarged upon by Professor H. C. Sherman,[14] who is a biochemist. Indeed, in general it may be noted that the dietetic regime for the prevention of caries introduced some thirty years ago is now the favorite, even though the theory and evidence on which it was based have been strenuously challenged.

The excellent results which followed its introduction[15] naturally induced research workers to take up the subject, but most of them were prejudiced by theories of nutrition rather than of hygiene, and but few knew enough about heredity and biology in general. Nevertheless, when we look at their recommendations we find in actual fact they often, presumably from clinical reasons, recommend a very similar dietary regime, the same number of meals and intervals between them, and the same sequence of foods as advocated more than a quarter of a century ago. To illustrate this a few quotations and observations from journals or books published many years ago may be useful to those who do not know that to many who had studied the question the problem was fairly satisfactorily solved some thirty years ago, so satisfactorily indeed that the late James Wheatley, after some five years' careful study of the subject, wrote: "The method of causation of dental caries is understood more thoroughly than that of the causation of any disease of the body."[16] With regard to still earlier pronouncements, it may be noted that in 1899 the modern view of how civilization affected the teeth was quite clearly propounded. Thus we read, "In the early periods of man's existence there was little social cohesion, and each individual had to a great extent to concern himself with securing food, and, when he had the opportunity or inclination, with cooking it. It is known, however, that cookery was indulged in from very early times. Even before the introduction of suitable utensils which could be used for boiling over a fire, it was to a certain extent managed by the introduction of hot stones into liquid foods, which were collected in whatever utensils were most con-

> venient for holding them. Methods were in use for roasting meat, fish, roots, nuts, etc., which, together with fruit, seem to have supplied the needs of remote savages. When we compare such a state of affairs with the various methods of securing food at the present day and the elaborate machinery (flour mills, rice mills, sausage mills, sugar refineries, meat juice factories, etc.) by which many of the foods are refined, not to speak of the processes to which foods are subjected in our bakehouses, biscuit factories and kitchens, we see that there is some difference in the food of the present day from that in past ages. It may be said, however, that after all the foodstuffs have not essentially altered. We require proteids, carbohydrates, fats, water and mineral matter, much in the same proportion as our ancestors, and that is what we get. There is one change, however, which has gone on and reached a stage which is absolutely detrimental to the well-being of the teeth, stomach, alimentary tract and body generally. There has been a gradual elimination of all the firm, fibrillar inert and undissolved earthy matters which are present more or less in the food of savages. The teeth are no longer used and burnished by these natural tooth-brushes and tooth-powders, and the stomach and intestines no longer have their movement sufficiently stimulated by the natural excitation of the foodstuffs."[17]

Further, it was maintained that:

> "It is important to note that although the food consumed at the present day is conducive to caries, it is not conducive to inherent or developmental deterioration of the structure of the teeth. The enamel is formed below the surface of the mucous membrane, and is complete in form and structure before it cuts the gum, and although the teeth are unused or only partially used, there is no reason to expect deterioration of structure."[18]

To those who knew the cause of caries fairly well all the research work that went on looked like a sheer waste of time. Happily during the last few years inferences from research, of which we have had an ample supply, have shown that the increase or decrease of vitamins A or D is certainly not generally associated with a corresponding increase or decrease of dental caries. This has been noted all over the world, more especially in field research work in England, Honolulu,[19] Sweden,[20] New Zealand[21] and South Africa.[22]

Now let me refer to the conclusions arrived at by the Caries Research Group of the Northwetern University Dental School. Here we note that the characteristics of children and adults who are claimed to be susceptible to dental caries are given. Similarly, the characteristics of those who are claimed to be immune are likewise tabulated. An analysis of these shows something of a quite remarkable nature, for the first point in each of these groups deals with the well-known fact that caries runs in families and races with well-marked regularity. But inasmuch as it was blood relations which were referred to, it is obvious that the implication was a biologically hereditary one, and not legal inheritance. But the extraordinary thing is that the remaining six summarized contrasting points given in this table are almost entirely a replica of the views I arrived at nearly forty years ago from a firm conviction, after prolonged study of biology with special reference to heredity, that blood relationship had nothing whatever to do with the problem. The relationship to my mind was simply what is now referred to as legal inheritance, and inasmuch as all the further observations of the Northwestern University Dental School indicate that dietetic habits and nature and choice of food control the incidence of caries, it really is impossible to say that blood inheritance is a controlling factor of any appreciable importance. Incidentally, here it may be noted that the experiments this school made "with the fortification of the diet with vitamin D have been wholly disappointing and produced no beneficial effects so far as caries susceptibility is concerned."[23]

In a leading article in the *British Dental Journal*, in 1931, we read:

"At the present time there are two main schools of thought which find a common meeting ground in believing that the prevalence of caries is to be explained by variations in the diet, and that its prevention could be insured by following certain principles. One school finds the explanation in an alteration of the physical qualities of the food whereby the fibrous elements have been eliminated, with the results that the food tends to stick to the teeth, and by its close contact favors the fermentation of carbohydrate and the formation of acid. This view . . . has found many adherents. . . The other school finds the explanation in the physiological factors in the diet and would explain the prevalence of caries by a deficiency of vitamin D which brings about defective calcification and thus weakens the resistance of the teeth to the exciting cause of caries. This view, with which the name of Mrs. Mellanby in this country and McCollum, Bunting and many others abroad is associated, depends on experimental evidence on laboratory animals in distinction to the first school which relies on clinical observations. There has been some tendency to depreciate views based on what is sometimes unkindly termed 'mere clinical observation' as being evidence not strictly scientific and less worthy of credence than work carried on in a laboratory. Perhaps this is no more than a passing fashion in medicine which is at present under the domination of the laboratory worker, but its existence has tended to produce an atmosphere favorable to a friendly reception of researches into the results of vitamin deprivation."[24]

At the International Dental Congress held in Philadelphia in 1927 Payne and Matheson gave a contribution on "The History of Dentistry in England," in which they referred to "the widespread influence" of doctrines propounded more than twenty-five years ago as the result of research we conducted in England at the end of the last century and the beginning of this. Now it would certainly appear from recent research in America that this widespread influence had been more pronounced in the last few years than ever before.

Altogether we may say that remarkable corroboration has been given to the original dietetic theory of the cause and prevention of dental caries as brought forward in England nearly fifty years ago, together with a salutary rejection of various theories which in recent years have confused dentists, medical practitioners and research workers, who were not sufficiently acquainted with the principles of biology, and other evidence which inspired and directed our work so effectually, that since 1910, and even more emphatically since 1914, the physiological or functionally stimulating, hygienic dietary regime has become so fully recognized as to have been introduced into the leading textbooks[23] for the teaching of dental students.

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# Chapter XXII

## FOURTH DECADE CONCLUDED

### *(Part 2)*

Unfortunately, toward the end of the fourth decade of the present century the Second World War had broken out and almost completely diverted attention from discussions associated with the prevention of dental caries and the newer knowledge of hygiene in diet. Nevertheless, the care of the teeth had to be carried on, and the history of what took place in this regard is to be recalled. So it seemed more than ever important to revert to what had virtually been established and reiterate the fact that: Some twenty years ago, I began to hear of the great interest which the work on nutrition of Professor E. V. McCollum had aroused in America. A little later I came to know that Dr. McCollum was interested in his subject with regard to the teeth.

Whether this had anything to do with it or not, I was invited to make a lecturing tour in America. The invitation was accepted, and at Baltimore my lecture was on "Recent Medical and Dental Research on Diet and Accessory Food Factors in Relation to the Prevention of the Diseases of the Teeth." McCollum kindly consented to open the debate, and at his request received an advance copy of my lecture. This debate, it was expected, would be the most memorable of all those that were made on this or any other subject upon which I discoursed. I am sure this expectation was not fulfilled. My communication was published in America,[1] but the debate initiated by McCollum was not, as far as I know. He said but little relating to my views, though doubtless the observations which he made with regard to experiments which he had been making may have been of interest to those who were concerned with nutrition.

I wanted to see, however, whether what I said at Baltimore, or what McCollum had read thereafter, had made any impression upon him with regard to hygiene in contradistinction to nutrition in diet. So some time later I read what he had to say in the fourth edition of his book, with the attractive title of *The Newer Knowledge of Nutrition* (1929). On turning to the chapter, "Diet in Relation to the Teeth," he begins with a section

"Prevention of Tooth Decay," saying: "There is no subject of greater importance to human welfare than the preservation of the teeth."[2] A little further on he gives a good though brief description of the process of caries as it occurs in teeth, in the following words:

"In caries the enamel becomes disintegrated and breaks down in a manner similar to what we should expect if acid were constantly applied to the surface of the tooth at one point. When a cavity is formed food particles and mouth secretions accumulate within it. It becomes the focus of fermentation with further production of acid."

But immediately following this he asks:

"Are the bacteria the primary cause of the carious cavity? Are there special kinds of bacteria which produce caries? Why do some persons escape caries while others develop it? Why is caries more frequent in early life than in later life? Why are caries and pyorrhea seldom found in the same mouth? Are there differences in the structure of the teeth which make some immune and others susceptible to caries? Is there a relation between diet and tooth decay?"[3]

Whether he had been much impressed by the answers I had given to such questions many years earlier or, what was much the same thing, with the "views held by all clear thinkers and accurate observers in the dental profession,"[4] what follows may indicate. In page 472 we read:

"The senior author" (i.e., E. V. McCollum) "pointed out several years ago that the only prospect of relief from the present deplorable condition of the teeth in America was through giving attention to the problem of forming sound teeth during the period of growth. He stated that this involves the application of scientific nutrition to the regimen of the expectant and nursing mother and to the management of infants and children, and stated that without satisfactory prenatal nutrition the teeth of the child will be faulty."[5]

Further, he said, "This idea has been accepted by almost all dentists and is now being emphasized as an outstanding feature of the campaign against tooth defects."[6] Strangely enough, however, when we turn to the concluding section of this long chapter on "The Diet in Relation to the Teeth," we are told that:

"Our" (i.e., McCollum and Nina Simmonds) "present incomplete knowledge indicates that diseased teeth result from: (1) Eating foods which do not demand chewing and consequent exercise for the teeth; (2) adherence of pasty foods to the surface of the teeth with resulting fermentation and attendant acid formation which etches the enamel; (3) unhygienic condition of the mouth; (4) probably also abnormal composition of the saliva which, when normal, should protect the teeth."[7]

In other words, at the end of the chapter, McCollum virtually abandons all that he seemed proud of having pointed out several years before the fourth edition of his work was published and emphasized it in an earlier part of this chapter by putting into italics the words in the quotation that

I have likewise put in italics. Let it be noted also that he and his lady collaborator in the fourth edition recognized from their "incomplete knowledge" that dental caries is the result of postpartum conditions, and certainly not more influenced by antenatal conditions as regards susceptibility to caries than are wisdom teeth which only begin to be formed seven or eight years after birth yet are notoriously susceptible to dental decay.

When we turn to the fifth edition of *The Newer Knowledge of Nutrition*, we find that the book has been entirely rewritten, and with regard to the section on "The Prevention of Teeth Decay" the views expressed therein are summarized by the authors recognizing "that an acid forming mouth flora, flourishing in great numbers, is the principal cause of dental caries,"[8] and that this view "rests upon stronger evidence than does any other theory."[9] Nevertheless, the authors still think that "there are certain puzzling problems which remain to be solved."[10] If they had said "remained to be learned by McCollum and his associates" they might have been nearer the truth. Let us analyze these "puzzling problems" with regard to the etiology of caries, which are referred to . They say:

"If this theory of the etiology of caries is sound, one would expect to find a high incidence of caries in pastoral peoples who subsist largely upon sour milk. There is an extensive literature supporting the view that sour milk drinking tends to the establishment of an acidophilus flora in the colon and, as pointed out above, Hadley and his associates could find no cultural characteristics which warrant separation of the intestinal and oral acidophilus organisms into two groups. Why do not these milk drinkers develop a profuse oral flora of the strong acid formers? Such evidence as is available indicates that excessive dependence upon milk as a food does not predispose to excessive caries of the teeth."[11]

But they add that "the excessive milk users eat relatively little cereal foods and do not therefore take a diet which would favor the formation of deposits of fermentable material in stagnation areas. This is probably of importance."[12]

From this time onward frequent allusion has been made to the harmful effect of the soft, milk-soaked, or pap diet in dental and medical literature by investigators in both of these professions.

Further, McCollum et al. do not seem to be aware of the evolution of the ideas with regard to the difference in effect of sour milk and diets of fresh milk, particularly when these latter diets are mixed with carbohydrates of a sugary nature and not followed by foods of a detergent nature. In my book entitled *Supplementary Essays on the Cause and Prevention of Dental Caries,* I wrote:

"There appears to be an idea that foods which are acid in themselves are harmful to the teeth; but clinical evidence does not support this assumption. When foods which are acid are taken into the mouth they stimulate a flow of alkaline saliva, not only when they are in the mouth but probably even after they are swallowed. This is analogous to the fact that chronic hyperchlorhydria is associated with marked alkalinity of the saliva. Moreover, acids are inimical to the acid-forming micro-organisms. . . ."[18]

Two or three years later a similar idea was brought forward independently by Professor William J. Gies, and a few years later Professor P. Pickerill championed similar ideas which became well-known in America. These were subjected to severe criticism by Professor Gies, not because they differed from mine, but because to him it was evident that the ideas Pickerill submitted in his book "had previously been stated in substance by Wallace."[19]

As a corollary to this "food acid" concept and evidence derived from clinical and field observations, I "noted that a distinction should be made between fresh cow's milk and sour milk, from the point of view of oral hygiene. The free acid in sour milk or buttermilk is not at all harmful to the teeth. Its acidity stimulates the saliva and the chances of a sufficiency of acid remaining about the teeth in such concentration as would injure them are probably nil."[20]

It would appear, however, that McCollum et al. knew little or nothing about these views, notwithstanding the prodigious show of literature on research work on the cause of the prevalence of caries in most civilized communities.

Let me now refer to a few other problems puzzling to those research workers like McCollum et al. who appear not to know the records of progress in this branch of science. In the fifth edition of *The Newer Knowledge of Nutrition*, the authors say:

"Another puzzling problem is why sugar eating is so effective in promoting the growth of aciduric organisms in the mouth in comparison with cooked starch eating. Cooked starch is pasty and adherent to the teeth and the diastatic ferments of the saliva would certainly form from retained starchy particles in a stagnant area a constant supply of fermentable sugar. One would expect cooked starch eating to be more caries producing than sugar, since sugar is so soluble that it can hardly be expected to remain long in the mouth. It is of course easy to visualize how sugar-saturated saliva would remain in pits and fissures and in stagnant areas, but it should do so to a lesser extent than cooked starch. Yet the present available evidence indicates that sugar is far more effective in inducing caries of the teeth than starch."[21]

From this it would appear that McCollum et al. follow inferences which Miller had made from laboratory experiments and his idea that the sugar was easily washed away. They do not recognize that clinical evidence, noted by dentists for many years before Miller published his researches, indicated that sugar was much more liable to cause caries in the human mouth than cooked starchy foods.

In 1903, I said:

> "With regard to sugar, the effect of refinement is particularly harmful. The refinement of the foodstuffs from which sugar is obtained is carried to such an extent that instead of the succulent tuber of the beet or the fibrous sugar cane we get the highly concentrated and crystalline product we know as sugar. Now it is known that sugar can be easily swallowed in quantity, and the result on the gastric digestion is to cause irritation and an excessive secretion of mucus in the stomach. I think, too, that this excessive secretion of mucus takes place in the mouth from like irritation. The harmful effect on both teeth and stomach is generally acknowledged. If, however, the sugar could only be got in the relatively unconcentrated form by chewing the beet or the sugar cane, the secretion of mucus might only be beneficial in coating the innutritious cellulose and putting it in a fit state for passage along the alimentary canal. Within limits, too, the mucus probably acts as a protective coating to the teeth. Moreover, retention of sugar in the mouth in a dilute form, together with fresh vegetable juices which accompany it in the sugar cane, stimulates the flow of saliva and facilitates its conversion into a less irritating and more assimilable form. The fact that the eating of sugar stimulates thirst suggests the natural need for its dilution, and the fact of the secretion of mucus suggests the adaptation of the organism to cope best with this article of diet when taken in the form in which Nature presents it to us."[24]

And towards the end of the same year I drew attention to the concomitant increase in the consumption of sugar per capita and the like increase of dental caries.[25] This observation has been repeatedly made from that time onwards without contradiction. Likewise, in 1907 and since that time, I have brought forward evidence with regard to the effect which sugar as usually consumed in civilized countries exerts in interfering with the physiological processes of oral hygiene."[26] This was overlooked by Miller when he based his inference with regard to the supposedly relatively rapid removal of sugar from the mouth as compared with starch. It may further be stated that Miller did not realize how the normal physiological effect of the saliva and ptyalin was exercised in the liquefaction of starch so that they facilitated the removal of this carbohydrate.

Let me now direct attention to the next paragraph on "Prevention of Tooth Decay" in McCollum's *Newer Knowledge of Nutrition*. It reads as follows:

> "Of peculiar interest is the effect of a high-fat-low-carbohydrate diet, such as is employed in the control of diabetes, in reducing susceptibility to dental caries. When lodged in areas of stagnation this type of therapeutic diet, while low in carbohydrate, must still provide an abundance of this substance for acid formation in pits, fissures, or incipient cavities formed by acid erosion. We suggest that another role of fat in the diet, viz., that of greasing the tooth surface and water-proofing it so that acid is prevented from actually coming into contact with enamel, or dentine when the

latter is exposed, may be important in protecting the tooth against even a high concentration of acid at a site of decay or potential decay. It is well known to chemists that many substances become coated with oil in preference to water when both liquids are simultaneously present. One may visualize the saturation of the debris lining a carious cavity, or a pit or fissure, with oil derived from fat food. This would tend to remain indefinitely on the caries-susceptible surface completely water-proofing it and shielding it from contact with acid arising from fermentation of food carbohydrate. This view seems not to have been previously recorded."[27]

Here again we note a curious lack of knowledge with regard to the views brought forward in the solution of the problem at the beginning of the century. In my book published in 1900 the two following paragraphs occur:

"The physical properties of fats in acting as lubricants to the foods taken with them are probably of some importance. I have made numerous observations which seem to me to indicate that the relative freedom from caries among people who eat much fat is out of all proportion to what one might expect if one considered fat as neutral in its action on the teeth. Nor do I think that we can account for this freedom from caries in fat-eaters by the fact that these people may eat relatively less carbohydrates.

"That eating of fat is not conducive to caries, if it is not positively inimical to it, has been proved by experiment by Dr. Miller[28] independent of any observations I have made, and it may further be mentioned that races which subsist largely on fats are peculiarly exempt from caries—e.g., Icelanders, Esquimaux,[29] etc.; and lastly, generally speaking, caries is less frequent and less rapid in people after the age when they begin to eat more fats."[30]

No less an authority than W. D. Miller made note of these observations of mine, and that in a prize essay published in America in the *Dental Cosmos*, December, 1904. In 1906 I noted his approval of my views by saying that "there is a reference to the fact that teeth covered with a film of fat are less readily affected by caries than when they are uncoated."[31] Notwithstanding this, McCollum et al. show how little they know the literature of dental research in America and England by saying: "This view seems not to have been previously recorded."[32]

Let me now direct attention to the problem from another point of view. Dealing with "The Natural Protective Coating of Enamel," McCollum et al. say:

"All dentists seem to agree that in many mouths the teeth fail to decay although they are hypoplastic, the enamel presenting the rough stained appearance illustrated by photographs in M. Mellanby's reports on experimental studies of dental caries. Such teeth are covered by a glary film that gives the mouth a filthy appearance and yet the teeth fail to decay. This fact has been brought forward as an argument against the view that the character of the enamel has anything to do with susceptibility to dental caries. Of interest in this connection is the work of several investigators with regard to the 'protective film' found on many teeth."[35]

They then refer to authors who gave the results of their researches in 1926 and 1933. If they had been acquainted with what I think is the earliest reference to this "protective coating," they might have avoided historical error, and incidentally might have spared themselves making an unwarrantable assumption that there is "only one possible way in which starch might exert a protective action against acid erosion."[36] In 1900, in a chapter on "The Prevention of Decay in Teeth." I said:

> "Let us consider Nature's methods of preserving the enamel. First, it may be preserved by being kept perfectly free from adherent matter as occurs on the crown surfaces of the teeth of those who eat coarse and non-lodgeable foodstuffs. Secondly, a protective layer of matter which does not become acid in reaction under normal circumstances may be deposited on the surface of the enamel and protect it from injury. Although this latter method is not recognized, I believe it is one utilized by Nature, and it is perhaps the only possible and satisfactory method at certain situations on the teeth. Hitherto this coating has received little attention. It has been considered as merely so much deposit from the mucus or the saliva in a vitiated condition, or from other sources, and it is assumed that this ought to be got rid of by the aid of the toothbrush as quickly as possible. . . .
>
> "Although there are micro-organisms which infect this coating where no carbohydrates are mixed with or adhere to it in quantity, acid is not produced, at least in any quantity. Morever, on account of the thinness of the coating even if a small amount of acid is at times produced, it is neutralized by the saliva. I have found that in the morning, even after having eaten sweets on the previous evening, this coating is neutral in reaction."[37]

Yet another instance may be given which shows how well-meaning, erudite and laborious research workers without either medical or dental qualifications may do more harm than good, especially when prepossessed by erroneous ideas. McCollum et al. say: "A fair appraisal of the evidence available seems to lead to the conclusion that the view of Bunting and his associates rests upon stronger evidence than does any other theory."[38] There are, however, weak points in Bunting's views in the estimation not only of McCollum et al., but also in the judgment of those who subscribe to the theory "more or less universally accepted,"[39] even although Bunting's views are now quite at variance with the nutritionalists' ideas. Thus, just recently, in an article entitled "What Procedures can be Instituted in the Infant and Pre-School Life of the Child for the Prevention and Control of Dental Caries?"[40] Bunting aptly concludes by saying: "Dental caries is not a deficiency disease: it is a luxury disease." This conclusion seems to me to be rather less explicit, though an acceptance of the observation I made in my lecture at Baltimore, the debate on which was opened by Professor E. V. McCollum. It reads as follows: "It is thoroughly well recognized that where the land flows with milk and honey there you have caries rampant in the classes which get these foods most, notwithstanding their vitamin content."[41]

McCollum et al. refer to other weak points in Bunting's views. Thus they say:

"The weakest point in the theory of Bunting lies in the attribution to sugar of a greater caries-producing power than cooked starch, and in the assertion that hypoplastic enamel, with its rough surface and pits, which from any standpoint should afford numerous areas of stagnation of food residues, is not more likely to favor decay than does normal enamel."[42]

I have already dealt with sugar. Here I would only refer to hypoplastic and rough enamel surfaces.

Further, McCollum et al. appear to think that M. Mellanby "has shown that incompletely calcified (hypoplastic enamel permits dyes to permeate it to considerable depths. One can visualize the permeation of such hypoplastic enamel by water or saliva, carrying into the enamel material which might serve as food for bacteria, and in severely hypoplastic enamel micro-organisms may be capable of finding their way below the surface of the enamel."[43]

The origin of and the motives which actuate investigators in arriving at conclusions usually give a good clue as to their validity. For this reason it may be well to trace the origin and development of the ideas which gave rise to the hypothesis that structural defects such as hypoplasia and rough enamel surfaces are the "fundamental"[44] causes of the prevalence of dental caries.

It would appear that a few years after the deliberate introduction of the catchword "vitamin." E. Mellanby commenced making experiments on dogs in the hope of showing that the vitamin then supposed to be of dominant importance in causing growth or some vitamin of like distribution was responsible for the normal growth of bone; contrariwise, that deficiency of this vitamin was responsible for the prevalence of rickets. His experimental investigations, it may be said, were instigated by certain conjectures by Gowland Hopkins, which presumably originated from Lunin's experiments and deductions, and possibly also those of Pekelharing. Unfortunately, E. Mellanby at that time did not recognize that it was an environmental influence that determined the incidence of rickets, such as the influence of sunlight, skyshine or ultraviolet light; nor did he recognize the important role which abnormal ratios of phosphorus and calcium in the diet had in the causation of the disease.

Following this, M. Mellanby took up the subject, and applied similar explanations to account for the prevalence of dental caries. She found that in at least some of the puppies which had been fed on the food and under the environmental conditions that E. Mellanby's experimental puppies were put, the enamel of the teeth of these dogs which were killed at the end of the experimental period showed the common form of hypoplasia familiar to dentists. Criticizing M. Mellanby's views put forward at this time, it was pointed out that this hypoplasia which she now calls gross or textbook hypoplasia, was brought on by disease which antedated, by some five years, the coming into place of the teeth affected, before the full eruption of the teeth in the human subject, and a like number of months in the case of dogs, and that consequently the whole or major part of the enamel of the crowns depicted by her had been formed before the experiments on the puppies were commenced.[45]

Following the exposure of her error in attributing the macroscopic hypoplasia portrayed to a deficiency diet administered after the hypoplasia had taken place, the Medical Research Council apparently tried to undermine the criticisms leveled at her work correlating the hypoplasia depicted with the deficiency diet, trying as I contended "to excuse the non-correlation of hypoplasia (macroscopic) and caries, and refers to further examinations of a microscopic nature made by M. Mellanby.[46] This is, however, no answer to the criticism. . . . It was visible, straight-forward, typical hypoplasia which was photographed, and it was this work which was severely criticized, and it was the criticisms to this work that the Medical Research Council seems to have evaded by referring to the subsequent work which was done on so-called 'microscopic' or 'occult' hypolasia."[47]

Then the Medical Research Council went on to indicate the correlation of microscopic hypolasia and caries, taking for its ground the new researches M. Mellanby had made. This in turn was shown to be untenable, as it was well-known to dentists, more than half a century ago, that the incisor teeth of the upper jaw were twenty times more liable to caries than the corresponding lower teeth, and yet the crowns of these teeth are formed at practically the same date. It was indeed evident that this so-called microscopic hypoplasia was not hypoplasia at all, on account of its position equidistant from the amelodentinal junction, and it was not the result of "a contemporaneous accretional deformity,"[48] which, according to the best authorities, is an essential attribute of hypoplasia. All this appears to have become recognized by M. Mellanby. Thus, in a recent discussion, replying to criticisims of E. W. Fish, she said: "She was afraid that Mr. Fish did not realize what she meant when she used the term 'hypoplasia.' She had tried to explain it over and over again, until she was tired of the word. It had been said many times in dental literature that hypoplasia as understood by the dental profession—textbook hypoplasia, or gross hypoplasia as she preferred to call it—might in many cases exist in teeth which never became carious . . . . but she felt that she did know definitely that teeth with what she called general hypoplasia were more susceptible to caries than normal teeth."[49]

When, however, we examine M. Mellanby's later work we note that what she calls general hypoplasia is not a dystrophy such as the "hpyoplasia which is defined as 'a deformity occurring along the lines of accretion contemporaneously in all teeth in process of development . . . .' "[50] Rather should we interpret her idea of generalized hypoplasia as being normal variations in the smooth, corrugated surface of the enamel together with some abnormal variations resulting from local metabolic disturbances such as are to be found in teeth when they erupt, that is of course before the freely exposed surfaces have been subjected to food of a fibrous or coarse nature inducing considerable friction during mastication. Before criticising her views, let me quote a few short extracts from her book on *Diet and the Teeth.* In Chapter II on "Abnormal Structure, (a) Surface Texture of Enamel," we read:

> "The routine method adopted for examining the surface texture of deciduous and permanent teeth either in the mouth or after shedding or extraction is as follows: A probe is rubbed lightly over the teeth, particularly over the labial and buccal surfaces. With practice the degree of roughness imparted by the 'feel' of the probe can be fairly accurately judged."[51]

Next, under subheading "Surface Abnormalities," we read:

> "As the result of examination by these methods very few teeth were found to have a smooth and shiny surface."[52]

> "Those superficial enamel defects which have been commonly recognized and which are so obvious to the naked eye, such as a definite deficiency or even absence of enamel in some regions, horizontal rows of obvious pits or a distinct encircling groove, are termed gross hypoplasia (see pp. 10 and 11). As will be seen in Chapter III, they occur in roughly 3 per cent of the deciduous teeth I have examined in the course of these investigations, a percentage which approximates to the figure usually recorded, 1 to 5 per cent."[53]

In the "General Summary and Conclusions," we read that:

> "In the Introduction, the criteria for a normal tooth were discussed so as to form a basis with which to compare other varieties of structure. Guided by the animal experiments, it was decided to recognize as perfect, a tooth with a smooth, shiny and creamy white surface."[55]

To those acquainted with the fact that on eruption the enamel of the tooth, in general, shows its surface on careful examination to have transverse undulations, sometimes called imbrication lines, together with some longitudinal striae and other local depressions each of which can be made more apparent by rubbing a dark substance such as graphite over the surface, it becomes evident that the "smooth, shiny and creamy white surface" in mouths which are physiologically clean is due to attrition resulting from the mastication of detergent foods. That this is the correct explanation is indicated even in her own observations on the processes associated with "arrested caries in children," for she notes that "the smoothing and polishing must result largely from mechanical action and will depend not only on the position of the cavity but also upon the physical nature of the food with which it comes in contact—the harder the food the sooner will the exposed surface become uniform."[56] Recognizing that a certain amount of attrition was normal when a proper amount of detergent foods was eaten, I went so far as to advocate decuspidation[59] when this had not been produced normally because of the withholding of detergent foods. As the late Dr. Harry Campbell states in his last book:

"The grosser forms of hypoplasia . . . . are rarely met with in the temporary teeth; in the permanent teeth they occur in about 10 per cent of persons. It is now generally accepted that they result from some temporary illness which affects the blood in such wise as temporarily to interfere with dental development. Surprising as it may seem, grossly hypoplastic teeth are only very slightly more liable to decay than normal teeth.

"The Minor Hypoplasias.—M. Mellanby finds minor hypoplasias, as affecting both the enamel and dentine, in the majority of British teeth, notably in children's teeth. . . . These minor hypoplasias are attributed by M. Mellanby to defective calcification (the result of deficiency of vitamin D, aided perhaps by excess of the anti-calcifying cereal factor) and are regarded by her, on the evidence of statistical findings, to be more liable to decay than ideally normal teeth; it is assumed by this school that dental caries is mainly the result of structural dental defect in which defective calcification plays a prominent part.

"There is overwhelming evidence as I have repeatedly urged in this book that the intimate structure and the degree of calcification of the teeth have little or nothing to do with the disastrous prevalence of dental decay among British people. The inherent liability of a tooth to decay depends essentially upon the degree to which it affords retentive areas for the lodgment of fermentable food: a polished dentine never decays; a rough (much more highly calcified) enamel is frequently found to decay. How then are we to explain M. Mellanby's findings, namely, that (a) minor hypoplasias occur in the majority of British teeth, and that (b) teeth thus affected are more liable to decay than others? Normal enamel is described by this observer as white, glistening and polished, showing no plainly visible irregular surface, whereas a tooth affected with minor hypoplasia is 'apt to be discoloured, rough and to show slight irregularities, pits and troughs.'

"Are we, however, justified in assuming that these features are wholly the result of innate dental defect? May they not largely be due to lack of detergent food and the consequent absence, or feeble action, of those agencies which tend to wear down normal enamel irregularities and to polish the enamel surface? . . . . Teeth which are not polished by detergent food retain a roughish or striated surface. Such teeth, Sim Wallace tells us, are 'apt to become carious, not because of any inherent imperfection, but because the detergent food which should have stimulated mastication and kept them clean, has been withheld from them.' I had myself arrived at the same conclusion.

"It is noteworthy that M. Mellanby, in treating of the minor hypoplasias, mentions their associations with enamel roughness, as also long cusps (which furnish retention areas and so predispose to caries), both of which conditions are manifestly the result of inadequate attrition.

"There would thus appear to be a twofold reason why children nurtured on a soft diet should suffer from caries more than others. Soft foods (1) fail to rub away natural cusps and so decrease the depth of the enamel surface, while at the same time they (2) tend to leave the mouth dirty, thus predisposing the teeth to caries. 'Smooth, polished, glistening enamel' points to a diet of a detergent kind, which not only leads to a grinding down of cusps and furbishings of rough enamel surfaces, but tends in many ways to maintain a high level of oral hygiene. This explanation disposes of an apparently weighty argument in favour of the structural hypothesis."[60]

Incidentally, it may here be mentioned that attrition can be carried to excess and by inducing conditions favoring food stagnation between the teeth bring on caries. This is noticeable in the skull of prehistoric man, and is probably one of the reasons why there is an instinctive objection to coarse and gritty food. Homo Rhodesiensis was obviously afflicted with caries, and in a recent letter in The Medical Officer I explained how this had obviously come about in accord with principles set out in the newer knowledge of hygiene in diet.[61]

Bearing on the question of caries and attrition in savages, Meyer Klatsky, in 1937, made a similar explanation of the incidence of caries in prehistoric man, including Homo Rhodesiensis.[62] At a later date, E. W. Fish made the generalization that "immunity of savage races to caries varies in direct ratio with the degree of attrition."[63] This, however, is not correct when the attrition advances beyond the contact point in such a way as to favor food packing between the teeth. Presumably, Dr. Fish may have had modern savages in mind, who, with the exception of the aboriginal Australian, almost invariably avoid the gritty matter in food which brings about excessive attrition.

Although the dental problem was solved and well-recognized before the outbreak of the World War in 1914, this latter interrupted the dissemination of knowledge already acquired. Moreover, certain problems in dietetics of a different nature, perhaps instigated by a partial recognition of the success which had attended this solution, distracted attention about the same time. Unfortunately, the problem of the prevention of caries had not been stabilized, and except to those sufficiently interested in the dental and biological data on which the solution was based it was necessary that research should be encouraged and conduced to bring home, or rather to spread abroad, the truths that had been made known in the first decade of the century. It is to a few of the research workers who continued effectually to stress the newer knowledge that I would refer.

In 1935, Meyer Klatsky contributed a valuable communication entitled "The Prevention of Caries by Proper Mastication," and noted that although as far back as 1900, attention had been called to the physical properties of food which tended to stimulate mastication and prevent the dental dangers arising from our civilized methods of preparing food, but little attention had been given to these ideas in either medical or dental literature.[64] Valuable though his contribution certainly was, in the following year he enlarged upon the subject and gave the results of his own investigation and experimentation, noting that with the cumulative historical evidence which he presented, he had undertaken the "study of the mouth of modern man with the object of determining the effect of our so-called civilized diets upon the teeth and their contribution to the prevalence of dental caries."[65] "The main objective of this study was to determine the exact relationship, if any, of the amount of stress exerted by the masticatory musculature to the frequency of dental caries."[66]

I need not here record the precautions which he took to secure trustworthy results before he proceeded to register and record the masticatory force of each of the first 100 individuals of ages best suited for the experiment.[67] The results were presented in two tables, one for the males and the other for the females. It was found, and in a striking and conclusive way, that the number of various cavities was inversely proportional to the force exerted in mastication.

The next communication of special importance for which we are indebted to Klatsky dealt with "Dental Attrition," which normally he shows is within limits likewise inversely proportional to the frequency of caries. For brevity I shall only give the first part of the summary:

"1. Dental attrition is not a pathologic but rather a physiologic process, the result of normal masticatory function.

"2. Function begets attrition. The two conditions are inseparable. There can be no attrition when the teeth do not function. The greater the function, the more extensive the attrition registered on the teeth. Therefore, attrition is the index of function, the yardstick by which, function can be measured.

"3. Dental attrition must be dissociated from dental diseases such as caries, erosion, and abrasion. . ."[68]

This communication must be regarded as a valuable scientific confirmation and addition to the evidence brought forward in the first few years of the century.[69] The essential similarity of Klatsky's views on dental attrition to mine may be indicated by the following quotation from a communication written now almost fifty years ago:

"There is a shape of tooth which is normal yet generally unrecognized as such; while on the other hand teeth are supposed to be normal in shape when they are wholly abnormal. For example, it may be asked, What is the shape of a normal first molar in an adult of normal constitution? In this degenerate age the answer would be something like, 'Its grinding surface presents five cusps. Four cusps are placed regularly at the four corners of a square, these being divided from one another by a crucial fissure,' etc. This description is, of course, totally incorrect, however accurate it may be for the erupting tooth. However, take the description, and make it as nearly the opposite as possible, and you will much more accurately describe the form of a normal adult's lower first molar tooth. Let it read, 'Its grinding surface presents five little hollows. Four cup-shaped depressions are placed irregularly at the four corners of a square, these being divided from one another by a crucial ridge,' etc. I need not elaborate this description. The point upon which I wish to insist, for it is of great importance, is that the grinding surface of a tooth ought, under normal circumstances, to show signs of wear greater or less according to the time the tooth has been in use. It is difficult to see how, for example, the first lower molar could possibly retain its deep crevices into adult life without running serious risks of lodging sufficient food and micro-organisms to initiate caries; whereas if a coarse and fibrous or otherwise normal diet is taken not only are the crevices kept relatively clean, but the cusps are worn down and the crevices become correspondingly shallower and less liable to lodge food; indeed, as the cusps get worn away first and the dentine is softer than the enamel, the crevices which are so susceptible to decay become somewhat more elevated than the surrounding cup-shaped depressions, and so less susceptible to caries."[70]

Klatsky, I am sure, had no knowledge whatever of the article just referred to, since it only appeared in the *Dental Record* nearly forty years ago, and moreover in all he has written, he, so unlike many others, has always given generous acknowledgment to forerunners in investigation similar to his own.

Now let me revert to another famous American biochemist. Professor Henry C. Sherman, unlike McCollum and others, attaches great importance to diet not only from the point of view of nutrition but also as it affects the teeth and alimentary canal before absorption, i.e., from the point of view of the hygiene of the mouth and alimentary canal. Thus in his book entitled *Food and Health* many of us who emphasize the importance of hygiene in diet must have been highly gratified to observe a very satisfactory exposition of such views as we have been endeavoring to get physiologists to appreciate for more than thirty years. Let me quote some passages bearing on this subject from Sherman's book:

"In the mouth, thorough chewing will reduce the size of the food particles to a minimum, thereby increasing to an almost unbelievable degree the surface exposed to the digestive juices not only in the mouth but throughout the alimentary tract. In the act of chewing the food is also moistened with saliva and reduced to a consistency in which it can be swallowed."[72]

In this we see that Sherman does not accept the idea commonly taught by physiologists that "when food is sufficiently ground, it is collected, enveloped in saliva, into a mass or bolus which rests upon the back of the tongue, and is carried backwards to the aperture which leads into the pharynx."[73]

Continuing, Sherman says:

"Each mouthful should be chewed until swallowing is entirely unconscious. Although relatively little chemical change in the food actually takes place in the mouth, thorough mixing of the food particles with the saliva makes for good digestion in the stomach where the food is stored for a period of time depending largely upon the size and character of the meal."[74]

Dealing with intestinal hygiene, he says:

"Fruits and many vegetables also have an important relation to the maintenance of good conditions in the intestine. This is largely because of the bulk which they impart to the residues, thus giving the muscular mechanism of the intestine a chance to be effective in keeping the residual mass moving and ensuring its elimination without undue delay, the fibre of these foods also serving to give the digestive apparatus 'its daily scrubbing.' This effect is, of course, shared by grain products which have not been too highly refined. Bran particles may easily be more laxative, but the softer cellulose of fruit and tender vegetables may be more important to intestinal hygiene in those cases in which an equal volume of bran residue would be too harsh. Many fruits and vegetables have also another valuable property, especially when eaten raw, in that the chewing of their fibre in the presence of the mild acids which the fruit and vegetables naturally contain is extremely effective in preventing the retention of pasty particles or mucus upon the teeth, while the acid also stimulates the flow of saliva and of the gastric juice. Thus the digestive process is helped and the mouth is left in the best possible condition. Hence, the great wholesomeness of raw fruit or fruit salad as a dessert, or of the eating of some celery or raw apple at the very end of (or directly after) a meal."[75]

On page 64 he says:

"Foremost among the factors involved in the hygiene of digestion are the selection and preparation of food and the eating habits of the individual."

On the following pages he refers to the texture of the food, a subject very frequently omitted in books on dietetics, and emphasizes its importance. He says:

"The very young and very old are not equipped to break up hard foods with the teeth and must therefore depend upon fluid foods or a soft, easily disintegrated food mixture. For others, a certain amount of dry, crisp food is normally desirable in that it tends to ensure healthy exercise for teeth and gums, thorough mixing of food with saliva and stimulation of the secretion of the gastric juice. Indigestible 'roughage' (cellulose) in reasonable amounts in the food gives bulk to the intestinal residues and helps to prevent their remaining too long in the large intestine. In general, as already suggested, fruits, vegetables and (for most people but not all) the whole grain cereals are of value in furnishing bulk."[76]

There is, I think, sufficient similarity in the foregoing two views on hygiene in diet as brought forward in my earlier books[77] to make me assume he may have been influenced by his colleague at Columbia University, Professor William J. Gies, who has long been well acquainted with my work, and generally endorsed it.[78]

A useful addition to Sherman's observations may be made by referring to the recent important investigation dealing with the incidents of dental caries, by L. C. Abrahams, for Sherman does not make any particular reference to the physiology of oral hygiene in relation to dental caries.

Commenting on Dr. Abraham's work, Professor J. C. Middleton Shaw says that supporters of my views of the cause of caries will find in Dr. Abraham's investigations "ample justification for their beliefs. As stated by Dr. Abrahams, the investigation shows clearly that 'the best means of combating caries is by the inclusion of crisp, fibrillar foodstuffs in the diet and the ending of each meal with an apple or similar food, as first advocated by J. Sim Wallace'."[79]

I do not intend to dilate on the valuable use Abrahams made of what may be regarded as one of Nature's excellent experiments well controlled by circumstances which were certainly not distorted by preconceived ideas. Suffice it to say that his inferences and associated experiments earned for him the degree of Doctor of Dental Surgery of the Witwatersrand University, which is by no means a small distinction, because in order to qualify for this degree it is necessary to write a thesis which "must be satisfactory as regards literary presentation and in a form suitable for publication, and must show original research."[80] What this means may be appreciated by the statement that "During the past fourteen years a considerable number of candidates have presented themselves for the degree, but only three have been successful."[81]

Dealing again with the same subject, in a later issue of *The Dental Magazine and Oral Topics*,[82] Professor Middleton Shaw reports that there are many supporters of what I designate the Newer Knowledge of Hygiene in Diet, and says it is in fact most interesting to note that nearly every investigation dealing with dental caries in South Africa adds support to the views which I have summarized under that title.

Now let us make note of the work done by Dr. Johan Brun, who was not without excellent qualifications to speak on our present theme.

While still a medical student he was "for some years assistant to Professor Lochmann, a much-respected professor in hygiene," and it was while still with him that he became interested in matters of hygiene. After taking his medical degree in 1892 he decided to become a dentist, and, accordingly in 1892-93 sought his dental education in Berlin, under Professor Miller.

It was in August 1894, however, that he first came in touch with real efforts on behalf of dental prophylaxis. I do not know all that he did between that time and the Eighth International Dental Congress held in Paris in 1931. This, however, I can say: he was appointed rapporteur to the section on prophylaxis at this congress, and from the published record of what he said we may regard him as one of the outstanding figures among the proponents of the newer knowledge of hygiene in diet with special reference to the teeth.

That his views coincided with those which I have tried to present may be judged from the following digest. He referred to the fact that A. T. Pitts maintained that I had done "splendid work" in connection with exogenous prophylactic measures, and that my views had become incorporated in the general body of dental knowledge and undoubtedly represented one of the most important advances in dental science since the work of Miller.

Brun also referred to my conception of the physiology of oral hygiene, which he said so far as he was aware had not been afforded the place in dental prophylaxis it deserved. He maintained that my theory should be taken up for profound study and that it would, to a very large extent, assist in giving us the knowledge considered so highly necessary and at the same time it would exercise a revolutionary effect upon the opinion physiologists held regarding the cavity of the mouth.

Further, he agreed that the fibrous element played an important dental prophylactic role, and in popular propaganda it has always been put forward as something definitely determined. He said he was "similarly convinced that the order of the ingredients in the meal" was important for the natural cleansing of the teeth, and consequently for dental prophylaxis. When introducing ordinary dental prophylaxis one can, of course, only bring forward that which has been clinically or scientifically ascertained as fact.[83]

After further useful discussion on the subject, Brun referred to the Oslo Breakfast. At that time he was Chief of the Dental School Clinics in Oslo. We know that the Oslo Breakfast was in accord with Brun's views and that the City Council decided to introduce it in the Oslo Folk Schools. Brun naturally insisted on the importance of "chewing hard fare." He said:

"On the introduction of the Oslo School Breakfast, we discovered that all the children attending the open air school had entirely lost this (chewing) instinct. They simply could not chew and we were therefore forced to teach them how to chew and to compel their natural, physical chewing ability to function."[84]

There have been several references to the Oslo Breakfast, both in dental literature and in the lay press, some of which have been distinctly misleading. It would be well if those who spoke upon this subject would take note of the further observations and injunctions which Brun himself made at the end of his communication at the Eighth International Dental Congress held in Paris.

Here may be noted that the Oslo Breakfast is composed as follows: 1/3 litre of whole milk, 1 Kneipp cracker baked preferably of wholemeal wheat, Kneipp bread with margarine and goat's milk cheese (as much of this as is desired) and ½ orange, ½ apple or 1 carrot according to season.[85] To those who are familiar with the recommendations put forward in 1900 more especially, and in succeeding years, it will be noted that the Oslo Breakfast follows closely on suggestions at that time, e.g., "coarsely ground wholemeal bread," "fresh vegetables and fruit." "more albuminous matter," and "fruit substituted for jam."[86]

Attention may now be directed to the application of the principles indicated in the foregoing, to school children in England.

During the term of office of Sir Frederick Menzies as Medical Officer of Health and School Medical Officer to the London County Council, an incident occurred indicating his appreciation of the newer knowledge of hygiene in diet. A dietary regime for the children in residential schools under the jurisdiction of the L. C. C. was introduced. I was first appraised of this by Mr. F. Breese, who was dental surgeon to one of these schools. What attracted his attention was the unusually clean appearance which he observed, shortly before he retired at the end of 1932, during his routine examinations of the children's teeth.

So impressed was he, being a convinced believer in the importance of diet for keeping the mouth and teeth in a clean and healthy condition, that he immediately asked the matron in charge if any change had been made in the dietary of the children. In reply, he was informed of new dietary changes, which included the eating of a piece of an apple or other fruit after the last meal of the day.

A year or two later I read what indicated that the regime promised to be quite a success. Later, however, I was informed—possibly incorrectly—that it had been abandoned, for on inquiry whether this was actually the case, I wrote at the instigation of Sir Frederick Menzies to his successor, Dr. W. Allen Daley, and in return received the present "Standard Dietary Scale for Children in Residential Schools and Homes."

Here I would only refer to a few points with regard to the nature of the dietary and the recommendations concerning its arrangement. In general it may be said that quite a large amount of the food was of the fibrous type, e.g., beef, mutton, liver, pork, bacon, rabbit, corned beef, sausages, fish; fresh vegetables in season; "fresh salads to be given frequently in the place of jam," and "every child to have 2½ oz. of raw apple every day, served at the end of the last meal, whether tea or supper."

It may be presumed also from the printed schedule that the children in these schools and orphanages were not supplied with sweets, as popularly understood. This is important, because in war time especially not only is the £50,000,000 spent on sweets a waste of money and harmful to school children, but it is also to a very large extent responsible for the need of school dentists to make good to some extent the ravages of dental caries.

Resulting from the success of the Oslo Breakfast regime, Sir Arthur MacNalty reports that the L. C. C. decided to try a controlled experiment under which a small number of necessitous children were fed for a time by the Oslo method, but local circumstances made it difficult to duplicate the method exactly for the purpose of making a clear-cut comparison with the results obtained in Norway. Thus, wholemeal bread was substituted for Kneipp crackers, and other changes were made. The only point in the report on the experiment to which I would refer is that the meal took "at least half as long again to eat as the two-course hot dinner, as there is so much hard food to masticate," thus emphasizing what I have for so many years insisted upon, the recognition of the value of food which stimulated the pleasurable activity of efficient mastication.

As in the leaflet for the use of parents on "the Prevention of Decay of Teeth," approved by the Society of Medical Officers of Health, we observe in the foregoing remarkable evidence of appreciation of the newer knowledge of hygiene in diet, as also of the practical means of preventing dental and associated diseases on such lines as were advocated and acted upon with the most gratifying success even as early as the first decade of the present century.

The foregoing chapter is simply an abridged epitome of an article which originally appeared in *The Dental Magazine and Oral Topics*, March 1940, Vol. No. 3, wherein the 88 references in the article referred to are given.

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# Chapter XXIII

## MEDICAL DICTATES AND DENTAL RESEARCH

### *(5th Decade,* 1941-1948)

In the fourth decade of the present century, the Medical Research Council evidently decided to abandon the phrase, "Accessory Food Factors," though it was perfectly satisfactory to denote the "stimulating principles" or "liberating stimuli" in foodstuffs, not only with regard to physical consistency but also with regard to their chemico-physiological detergent qualities. Moreover, it was quite inauspicious to substitute the word vitamin which was virtually based on a term that, as L. J. Harris[1] records, was by no means a scientific procedure. This being so, discussion on the nature and causes of the prevalence of dental caries, irregularities of the teeth and pyorrhea alveolaris continued.

The first medical research in the fifth decade of this century to which I would refer was contributed by Irene Allen,[2] University College, London: Assistant to the late Dr. Matthew Young, M.D., D.Sc.

I need only give the first part of the Summary in which it was recorded that "120 elementary school children were examined over a period of one year for dental caries and structural defects of the teeth. It was found that: (1) The lower incisors and canines showed the best surface structure and the molars the worst, the upper incisors and canines being intermediate; the structurally soundest teeth are therefore those of which the greatest part of the teeth is formed *in utero* before dietary deficiencies are normally felt by the child.[3] To this is only necessary to remark that it has been well-known by dentists certainly ever since Magitot and other highly distinguished odontologists showed that the upper front teeth were effected with caries more than twelve times more frequently than were the corresponding lower teeth and they all knew perfectly well that the greatest part was formed *in utero* long before dietary deficiencies were normally felt by the child, but neither Magitot nor any other observant dentist ever claimed that (2) A definite association existed between the quality of the teeth and the amount of caries present. It has, however, long been recognized that the teeth which are most liable to be attacked by caries are those which have stagnation areas, either on the easily visible, or on the adjoining surfaces which interfere with the normal self-cleansing processes.

Now let me continue with a quotation taken from the "Summary of a British Medical Lecture" by Sir John Boyd Orr, M.D., FRS.,[4] published in the *British Medical Journal*, January 18th, 1941. He begins by saying: "The treatment of disease falls entirely within the sphere of the medical profession. There has consequently been little delay in applying the advances in our knowledge of nutrition to the treatment of deficiency diseases. But for the prevention of deficiency diseases we need a supply of protective foods sufficient for the needs of the whole population and at a price within the purchasing power of everybody. This involves economic and political problems which are regarded as being outside the sphere of medicine."

No doubt this is true, then he goes on to say: "What we are dealing with is not diets deficient in one or two constituents but diets deficient in many. In tests the improvement got by giving one nutrient, such as vitamin A, is negligible compared with the improvement obtained by giving milk, which is rich in most of the elements deficient in a poor diet. This is well exemplified in the case of teeth. Deficiencies of vitamins D, A and C, of calcium, and of magnesium; the effect of carbohydrates in promoting the growth of B. *Acidophilus* odontolyticus, which attacks the enamel; mechanical chewing, which affects the growth of the jaws and the tooth-spacing, all help to determine the condition of the teeth. But the correction of any one of these factors will not ensure healthy teeth. Schioitz found in his extensive investigations that the children who had perfect teeth some had had cod-liver oil, some had not; some had been given sweets, some had been kept off sweets; some had brushed their teeth and some had not. But every child who had perfect teeth had had an abundance of milk and green vegetables regularly, without a break."[5] From what I have just quoted it would appear that Sir John Boyd Orr had not recognized what many dentists have known perfectly well ever since the beginning of the present century, namely that with the advent of civilization together with the refinement of foods and notwithstanding the increased consumption of milk, dental caries and defective development of the jaws had correspondingly increased. Cups full of milk can supply all the nutriment required by the child, but after it has several or all its temporary teeth, milk will not stimulate mastication which is requisite for the full development of the jaws, and the promotion of the adroit activity of the tongue in the natural cleansing of the teeth. Neither will platesful of milk puddings sweetened with cane sugar stimulate mastication; but these and other forms of pap feeding may well account for the squashing of food into stagnation areas and depriving the child of the pleasurable activity of efficient mastication. It was on account of this that crusts of bread were advocated as liberating stimuli, and when the milk molars had come into position such foods as apples even though less nutritious than milk, were recommended to terminate the meals. Of course an abundance of green vegetables would subserve a similar purpose.

There is a simple and obvious explanation of the wisdom contained in the quotation which Sir John Boyd Orr made in reference to the investigation of Professor Carl Schioitz (Oslo), saying that "Every child who had perfect teeth had had a abundance of milk and green vegetables regularly without a break." This, however, suggests that it was the abundance of milk and *the abundance of green vegetables without a break* which were most important in ensuring the development and the preservation of perfect teeth.

When we remember that all the Mammalia except man are never brought up in early life on two different kinds of food mixed together at the same meal we can question the advisability of a mixed meal before the temporary teeth have come into their normal position.

Should we not take note of the instinct of a child? Up to the age of six months or till the incisor teeth begin to erupt, a child's instinct is thoroughly satisfied with milk taken from its natural source: after this, it begins to like to gnaw such suitable foods as crusts. Pap feeding from this time onward cheats the infant of gratifying its instinct to gnaw any suitable food before being coaxed into gulping its food, ladled into the mouth with a spoon. Certainly when any infant takes milk from its mother's breast it is not soaked with bread or other food containing carbohydrates. In a communication by Professor Schioitz which appeared in the *Norske Tannlaegeforenings Tidende* (January, 1937) which was translated and published in *The Dental Record* (April, 1937)[6] the following few sentences may be quoted. "From certain quarters it has been maintained that the main point is the physical consistence of the food, and not the chemical nature of the nutrients or foodstuffs. The author is greatly interested in food that requires chewing, as has been demonstrated in practice by the school breakfast composed by him and introduced in many cities and towns in Norway—the so-called 'Oslo breakfast' which comprises whole meal crackers or whole meal bread ('knekkebrod') carrot or apple, as well as milk, brown bread and cheese, and at certain times of the year oranges. Half an hour is fixed for this meal, in order that the children may have *time* to chew the food. On the walls of the eating-rooms in several schools is put up the following notice: 'Never drink with food in the mouth.' This is the only method for ensuring the desired chewing—to urge the children—or adults (1) to chew the food well is of no avail."

After referring to the inhabitants of Tristan da Cunha, the Hebrides and elsewhere he says: "But the inhabitants of Tristan da Cunha, the Canary Island, the Hebrides and of certain districts in Italy are practically free from caries, and yet their food is soft."[7] (I also referred to the excellent condition of the teeth in Tristan da Cunha and the Hebrides but noted that it was only in the districts when there were sweet shops that caries was found to be present.) . . . "Accordingly, (as claimed by Schioitz) a geographical consideration of the problem refutes the view that the consistency of the food is a *conditis sine qua non.*"[7] That freedom from caries is sometimes due to geographical conditions is very well shown in Tristan da Cunha because its geographical position makes the import of sugar and sweets an extremely rare occurrence. (J.S.W.) Why also did I conclude an address delivered to many important societies in Canada and the United States of America over twenty years ago by saying: "It is perhaps significant that man has chosen or prefers to eat toasted white bread with bacon and egg. Instinctively, he does not want to upset his liver with too much egg, nor to have a good meal spoiled with an excess of vitamins.

"Of course, there are many other points to be considered. White bread appears to keep better than brown bread. It certainly toasts better, and with bacon it tastes better. While toasted bread stimulates mastication, this can hardly be said with regard to an egg. A rasher of bacon, however, together with the toast, supplies most excellently all that is necessary from this point of view.

"A good meal may easily be changed into a bad one, and this is often still done by finishing it off with bread and marmalade, jam or honey. There is ample sufficiency in the egg and bacon breakfast without this tooth-destroying addition, but if a special finish is required, apart from taking the coffee last, the hygienic termination can easily be got from fresh, firm fibrillar fruit full of fragrant flavour."[6]

Surely it should have been obvious to Sir John Boyd Orr and Professor Schioitz that the arrangement of the foodstuffs in mixed meals was particularly important, but from the communications given by those two highly distinguished leaders of thought in the medical profession it would appear that both of them ignore two important points with regard to the prevention of dental caries. The first to which reference may be made is that dental caries is *not a deficiency disease* as has been noted by Bunting; and several other highly distinguished dental surgeons recognize this: the second point is that it is chiefly among the children of parents who are well fed from the point of view of *nutrition* as recommended in medical textbooks that we most frequently find an excessive amount of dental caries. It has indeed often been said that "the better the school the worse the teeth," but Sir John Boyd Orr concentrates on nutrition. He says: "In tests the improvement got by giving one nutrient such as vitamin A, is negligible compared with the improvement obtained by giving milk, which is rich in most of the elements deficient in a poor diet. This is well exemplified in the case of the teeth." Unfortunately neither Orr nor Schioitz seem to take any particular interest in making it clear that the abundance of milk came or should have come first and the abundance of green vegetables presumably came after the milk had been consumed. It might well have been explained that many eminent dentists and a goodly number of Medical Officers of Health recognized carbohydrates, fats, and mineral salts, together with, or rather followed by stimulating principles such as are found in fruit and vegetables which induce a liberal flow of saliva and facilitate the adroit detergent action of the tongue in maintaining the mouth and teeth in a clean and healthy state. Some of us have likewise advocated bulk and innutritious matter e.g., the late Sir Henry Thompson. Incidentally, I may mention that it was from the 10th Edition of Sir Henry Thompson's book on *Food and Feeding*, published in 1899, my attention was directed to the value of cellulose, which has a fibrillar texture such as promotes mastication. Although the observations of Sir John Boyd Orr and Professor Schioitz and other eminent members of the medical profession may have paid some tribute to my views and precepts, there were few who followed the history of the vitamin on which much stress was laid, namely fat soluble A. Possibly it may have originated in some one noting a sentence in my first book. It reads as follows: "The physical properties of fats in acting as lubricants to the foods taken with them are probably of some importance. I have made numerous observations which seem to me to indicate that the relative freedom from caries among people who eat much fat is out of all proportion to what one might expect if one considered fat as neutral in its action on the teeth. . . Nor do I think that we can account for this freedom from caries in fat-eaters by the fact that these people may eat relatively less carbohydrates." (Decay in Teeth, 1900, p. 9).

That eating of fat is not conducive to caries, if it is not postively inimical to it, has been proved by experiment by Dr. Miller,[9] independent of any observations I have made, and it may further be mentioned that races which subsist largely on fats are peculiarly exempt from caries, e.g., Icelanders and Esquimaux,[10] etc., and lastly, generally speaking, caries is less frequent and less rapid in people after the age when they begin to eat more fats.[11] That a few teaspoonsful of milk should be all that is necessary to transform a thoroughly purified diet, devoid of stimulating principles such as lactose containing a gritty powder or the fibrillar cellulose in the husk of the grain is not so very surprising, since, apart from nutritious substances, milk contains lactose, (saccharum lactis), a sugar obtained from whey of cows milk, $C_{12}H_{22}O_{11}+H_{20}$ which occurs as a gritty powder of moderately sweetish taste."[12] What indeed could be more satisfactory for supplementing a thoroughly purified diet devoid of stimulating principles such as lactose or cellulose? Contrariwise when cane sugar is substituted for lactose, then the so-called purified diet becomes most dangerous with regard to the preservation of the teeth, if it is not followed by fresh fruit or some other detergent food.

Nearly fifty years ago I referred to the part which cane sugar took, giving Schutzenberg's chemical equation explaining what theoretically takes place,[13] adding that: No doubt this viscous gum (mannite) acts as a very effective barrier to the influence of the saliva, and as this fermentation takes place along with lactic acid and other fermentations, and the deposited gum acts as a food-catcher, retainer, and acid fermentation protector, we need scarcely wonder that there is a popular impression that sweets are bad for the teeth.[14] Now let us refer back to Sir John Boyd Orr on Trends in Nutrition. In this he notes the fact that—"On Tristan da Cunha the dietary consists of potatoes, vegetables, fish and milk, with addition of penguin eggs when they can be obtained."[15] Professor Schioitz apparently regards this diet as soft, (Footnote *Dental Record*, p. 185) but on consulting Douglas M. Gane's book on Tristan da Cunha we read that the potatoes are eaten "bare"—"that is potatoes eaten without salt and unaccompanied by tea or any other food; fish they eat with nothing else, and penguin eggs—perhaps three at a time—are eaten alone."[16] In this same book there is a passage taken from Augustus Earle's book, in which he describes the effect of residence on the island on *himself*; and for what it implies . . . the following extract from the passage is worth perusal. As already suggested, the prevailing health on Tristan da Cunha may not be due so much to what the island diet contains as the moderation which now, as in the early days, marks the island's consumption of it, and it may well be that in this connection Mr. Earle's allusions to the benefit of abstemious living will carry weight. He says: "Exercise and temperance we all believe to be greatly conducive to health. Five months residence on this island has convinced me of their wonderful effects on the constitution. Here our food is of the coarsest description: bread we never see: milk and potatoes are our standing dishes: fish we have when we have the chance to catch them: and flesh when we can bring down a goat. . . These last few months' experience has done more to convince me of the 'beauty of temperance' than all the books that have been written could have done."[17]

Surely it is obvious that the prevalence of caries in civilized countries is not that the essential dietary constituents have been absent. Rather should we say that the chief cause of caries in civilized countries is due to the sucking of sweets and the overindulgence in such foods as cereal milk puddings, sweetened with cane sugar and swallowed without mastication. It would be rather whimsical to say that the prevalence of dental caries in Britain, the United States of America, Australia, New Zealand, etc., was due to an insufficient supply of essential dietary nourishment.

That a trivial amount of milk should be all that is necessary to transform a thoroughly purified diet, i.e. one which is devoid of stimulating principles, such as lactose with its gritty powder, is not so very surprising, since, apart from other nutritious substance, milk contains lactose, "saccharum lactis, a sugar obtained from the whey of cow's milk . . . occurring as a gritty powder of moderately sweetish taste."[16] On the other hand refined cane sugar, sucrose, undergoes a mannite or gummy, as well as acid, fermentation. What could be more satisfactory for supplementing a thoroughly "purified diet" which is devoid of stimulating principles such as lactose and substituting cane sugar which is liable to produce mannite a gummy material which adheres to the enamel of the teeth especially in crevices of, or between the teeth, where it is not rubbed by the tongue, cheeks, or detergent foods and washed away by the saliva during or soon after the food has been swallowed?

Reiteration of some few paragraphs in my communication to the *Journal of the American Dental Association* and *Dental Items of Interest* on the Newer Knowledge of Hygiene in Diet[19] would assuredly substantiate the attitude I have taken up in the foregoing pages. But for my purpose, at present it is only necessary to indicate the trend of ideas with regard to vitamins in the Newer Knowledge of Hygiene in Diet. So I shall simply refer to a few which are concerned with the prevention of *Dental Caries.* To this end it is only necessary to direct attention to part of an article to be found in the *Journal of the American Dental Association* for July 1931 pp. 1331-1332. "More by good luck than by design and perhaps unconscious of the fact, Mrs. Mellanby has shown most conclusively that even though puppies have been subjected to deficiency diets, and vitamin D has been excluded during development, even excluding prenatal life, and though this has no doubt been done with scientific rigor in laboratories under her supervision, as an almost invariable, if not invariable, rule, the teeth of these experimental animals never become carious. I understand that dogs in this country are practically if not entirely free from caries. I gather that vitamin D is rather limited in its distribution. It is found abundantly in cod-liver oil. It is present in the yolk of eggs. Cream and butter contain small but generally appreciable amounts. Nevertheless, children who do get these foods are extraordinarily subject to caries, while dogs, which seldom get these luxuries, manage to keep free from the disease. Mrs. Mellanby tells us that 'as a matter of fact, the diet and general metabolism of the domestic dog is as near that of the human being as any other living thing'."[20] It seems to follow, if we are to put any value whatever on animal experiments, that deficiency diets, at least diets deficient in vitamin A and D, should never cause caries in human beings. It is curious that the obvious corollaries of her experiments should still frequently be overlooked. No doubt, we shall soon have research purporting to show that the absence of these vitamins causes or predisposes to caries in human beings, and, if so, what has become of the value of animal experiments which show precisely that this does not take place?

I wonder what ideas a little quiet reflection will arouse when the blinding enthusiasm for vitamins has passed? On the one side will be seen the solid tangible work of the dental profession, notably the common sense observations of Parmly and Robertson, carried forward by the work of bacteriologists from Pasteur onward. They will note the reliability of the work of Miller and others who clearly elucidated the nature and pathology of dental caries. They will see the importance of the work of Magitot and Miller in demonstrating the experimental method of the production of the disease. They will observe the outstanding work of Black, Tomes, J. Leon Williams and others, all of whom, notwithstanding some mistaken ideas, contributed valuable and reliable data which helped to lead to the possibility of more or less complete elucidation of the cause of caries, and allowed us to define this clearly and introduce the methods of prevention now widely recognized to be effective. On the other hand, they will note how the medical and dental professions were distracted by vague ideas about metabolism even in inorganic matter. How they were frenzied with hope that the prenatal and postnatal administration of drugs containing vitamins would allow us to dispense with the necessity of attending to the dictates of the physiology of oral hygiene, and alimentary hygiene in later life, and how they were misled by animal experiments which, on analysis, proved little or nothing except that the leaders of thought of the dental profession were right from the first and all the time. The pity of it all is that the knowledge which had been slowly gained by many years of painstaking investigations was obscured for well-nigh a decade from those who otherwise should have been disseminating the knowledge which was and still is so urgently required. As the editor of the *Medical Press and Circular* recently said: "A vast amount of disease results from neglecting to apply our present knowledge. . . We know how dental caries can be prevented. . . It is exasperating to know that we have it in our power to check an untold amount of disease by the simplest possible means and that we fail to use that power."[21]

Reiteration of the foregoing paragraphs was stimulated recently (August 1948) by a large and elaborate advertisement extolling the wonderful merits of their *methods of vitamin assay*. But for my purpose, at present it is only of interest to indicate the trend of ideas with regard to vitamins in general, so shall simply refer to a few which are concerned with the prevention of dental caries. To this end it may be well to refer to an article to be found in a book of outstanding importance and utility entitled *Dental Caries* compiled for the Research Commission of The American Dental Association (1941). Therein the Findings and Conclusions on Its Causes and Control are stated in alphabetical order. Here, however, it is impossible to do more than give a reference to one of the best summaries in this book. It is taken from the researches of Eric W. Fish, M.D., Ch.B., L.D.S. (Manch.), D.D.S., (Melb.), D.Sc. (London): *Meyerstien Laboratory for*

*Dental Research, St. Mary's Hospital, London, England, (April 8, 1940).* Herein he states that: "Attempts to alter the calcium content of dentin have been ineffective; it is still more unlikely that enamel could be altered. Tissue fluid cannot reach the carious lesion, and clinical attempts to treat caries by nutritional methods have been useless. Caries can, however, be held up indefinitely by local chemical treatment (e.g. silver nitrate in children). . . Caries is a bacterial decomposition of tooth substance, which can be affected by local conditions, such as food stagnation and fermentation, or immunologically through the saliva. . . The calcium content of dentin cannot be altered, once it is formed, by administration of vitamin D or by calcium starvation in pregnancy. As soon as dentin is contaminated by toxic products of a carious lesion in enamel, that area of dentin is at once cut off from the pulp by an impermeable barrier of calcified matrix."[22]

With regard to the dental health the author of the book entitled *Tristan da Cunha* published a letter in *The Times* of February 22, 1932 which initiated a discussion on the subject and recalled the fact that Mr. E. W. Fish, of the Hale Research Laboratory, Royal Dental Hospital of London, in a letter also to *The Times* suggests that the explanation of the phenomenon is to be found in heredity.

Mr. Fish's suggestion was that the people of Tristan da Cunha have inherited a caries-free tendency, and that this tendency persists because "they have been a closed community for many generations, free from any outside racial admixture." This latter statement by the author of the book on Tristan da Cunha controverts in a subsequent letter. "It is not a fact (he says) as Mr. Fish suggests . . . that the inhabitants have for generations formed a closed community without any racial admixture. Though living in isolation as they are, it is really just the contrary, for, as the exhaustive report prepared on the visit of H.M.S. Odin in 1904 states the people have come from diverse stocks. Though Scottish in origin from the nationality of William Glass, the founder of the settlement, they have from time to time been refreshed from English, American, Dutch and Italian sources. . . The arrival at intervals of new blood on the island has been inevitable, if only from the seventeen shipwrecks which have occurred there, and any explanation of the physical condition of the islanders in point of heredity, as Mr. Fish suggests, is on that account ruled out."[23]

Further references here to the many other controversies given in *Dental Caries* may be deferred especially because biological and legal heredity are so frequently confused. So to end this part of the controversy I shall give the words of John Tomes, F.R.S., and Charles S. Tomes, M.A., in their Second Edition revised and enlarged in 1873, which ends with "The following conclusions seems to be most nearly in accordance with the preceeding facts, viz:

"That caries is an effect of external causes, in which so-called 'Vital' forces play no part. That it is due to the solvent action of acids which have been generated by fermentation going on in the mouth, the buccal mucus, probably having no small share in the matter; and when once the disintegrating process is established at some congenitally defective point, the accumulating of food and secretions in the cavity will intensify the mischief by furnishing fresh supplies of acid."

Before passing on from this discussion on dental caries, I should like to refer to a few sentences in the preface of the second edition of the book entitled *Dental Caries*. It refers to what Oliver Wendell Holmes said with universal acclaim: "The best test of the truth is the power of thought (finding) to get itself accepted in the competition of the market. 'Error of opinion may be tolerated where reason is left free to combat it.' (Jefferson, 1801). 'There need be no fear that any views, unsupported by convincing evidence, will be seriously misleading. Researches in the future as in the past will nullify misjudgments."[24]

Reverting now to why the Medical Research council had discarded the phrase "accessory food factors" notwithstanding its endorsement by the late Sir Gowland Hopkins, let me recall the fact that Professor D. Fraser Harris had condemned the word vitamin as meaningless and absurd, and moreover that it was admittedly introduced as a catchword which, however, struck the imagination of the public. This was followed by several other vitamins in alphabetical order. Let me quote what Mrs. Mellanby said in a paper entitled: Experimental Evidence Demonstrating the Influence of a Special Dietetic Factor on the Development of Teeth and Jaws.

"The name vitamin was given to these bodies because Funk claimed to have isolated one member of the group and found that it was an amine. Although these results have since been shown to be incorrect, yet the name has struck the imagination of the public and it is certainly more concise than the term 'Accessory Food Factor' used by Professor Gowland Hopkins, who was the first to appreciate fully the great importance of those substances as a result of his pioneer work."[25] On the following page we read about Fat Soluble A, and that "It is present in green vegetables."[26] A few lines further on Mrs. Mellanby says: "Vitamins have one important property in common in that only vegetable life can synthesize them."

Now let us see what soon became recognized with regard to fat soluble vitamin A. In 1889, Huntly brought forward evidence which strongly supported his idea that absence of sunlight was the chief cause of rickets. T. A. Palm, in 1890, also showed the importance of sunlight, and indicated by "the geographical method that rickets abounds where light is lacking and is unknown where light abounds." Soon after the discovery of vitamins, it was assumed that rickets belonged to the class of vitamin-deficiency diseases. Mellanby suggested fat soluble A, or one closely associated with this factor. When this was shown to be untenable, an unknown vitamin (X) was accused by Park but acquitted. Later, in Berlin, Professor Huldschinsky showed that rickets could be cured by irradiation with ultraviolet light. Then, Alfred F. Hess, of Columbia University, New York, showed that rats fed on a rachitic diet recovered if to it there were added portions of the skin of an animal irradiated before death, whereas the addition to the dietary of a skin of a nonirradiated animal was useless. In short, irradiation produced "vitamin D" in the skin. From this, it was a short step, taken notably by Professor Steenbock in Wisconsin, to produce vitamin D by irradiation in foodstuffs. Though not depreciating the value of cod-liver oil, Findlay and Paton stressed the value of exercise, fresh air and hygienic environment and showed that the fat soluble vitamins were not necessary if the diet were otherwise reasonable. Perhaps by way of mitigation of the erroneous ideas of Professor Mellanby, and to try to keep to some vitamin theory, the substance which was produced by irradiation was called vitamin D. But according to experts and as unequivocally stated by Mrs. Mellanby, "vitamins have one important property in common in that only vegetable life can synthesize them." Thus, in their conception of the nature of vitamins, the antirachitic factor, irradiated ergosterol, is not a vitamin at all. Unfortunately, although he has had to abandon his fat soluble A deficiency vitamin theory of the causation of rickets, Professor Mellanby apparently rather misled the medical profession in this country for years, and hindered the appreciation of the newer knowledge of the causation and prevention of rickets, dental caries and the irregularities of the teeth, which from the point of view of both children and adults in civilized communities is of outstanding importance. Nevertheless, he has not been altogether successful, and, even with regard to rickets, there is still certainly no clear evidence that it is a deficiency disease, although its prevalence can be diminished or possibly the disease might be prevented altogether by the substance (irradiated ergosterol) which acts antagonistically to the incidence of the disease. Indeed, it has not by any means been proved that rickets is not caused by a positive substance resulting from unhygienic environment and the administration of unsuitable foods during rapid development.

It is not my intention to refer to the many conflicting views summarized in the work on *Dental Caries* giving the Findings and Conclusions on its Causes and Control; stated in 237 summaries by observers and investigators in twenty-six countries. Having already indicated the general trend of ideas before 1941, let us note the state of affairs when a child is brought up on a thoroughly purified diet which is devoid of stimulating principles such as lactose, cellulose or other innutritious substances. When the molar teeth with retention areas for food particles on the grinding surface come into position surely detergent foods are indicated for the cleansing of the teeth and the stimulation of the growth of the jaws as well as the muscles of mastication and the tongue which helps very materially to coordinate the proper relation of the upper and lower arches of the teeth. This normal relationship of the tongue, cheeks and lips not only further facilities the normal self-cleansing of the teeth but also adds to the beauty of the face.

Meantime consider another correlated factor associated with the natural physio-chemical method of preventing dental caries in young children which was forced on my notice while reading a brief note in the Annual Report of the School Medical Officer of the Borough of Bury St. Edmunds. He refers to Messrs. Sarginson, Hales and Laville, three dental surgeons who devoted much time to the inspection and treatment of elementary school children. The school medical officer was most grateful for their public-spirited action which it is certain the dental profession would heartily commend. The whole report is most interesting, and the school medical officer appears to take a special interest in the condition of the teeth of the five-year old group of children. He referred previously to an improvement in the dental condition of entrants, and he was able in the year 1944 to report that the improvement was maintained. Table B of the appendix shows that the percentage of 5-year-old children with good teeth, which was 28% in 1934 and 55% in 1939, rose in 1944 to a new high record of 73.5%.

The school medical officer attributes this *spectacular improvement* to a reduction in sweets available to very young children; the improvement in the nutritional value of wartime bread and to the largely increased consumption of fruit and vegetables during war. Statistics like those submitted are fast becoming commonplace, and it is not without interest that a member of the medical profession should make a point of emphasizing the general opinion though the numbers in this case are small.[27] May not a correlated factor in this "spectacular improvement" have been the incorporation of prepared chalk in the bread?

Hale White in the sixteenth edition of his well known textbook on *Materia Medica* gives the characters of this as: "White friable pieces of a dull white powder," and of precipitated chalk as,—"a white crystalline powder insoluble in water." With regard to the action of calcium (chalk) internally he says: "Very nearly all of any calcium salt is excreted unchanged in the faeces." . . . With regard to absorption, Hale White says, "When calcium salts are taken, small quantities are absorbed; most of that absorbed is excreted by the epithelium of the large intestine, the rest by the kidneys. Calcium is necessary for all forms of protoplasm, thus many lowly organisms die when placed in water from which it is absent. . . Internal—*Alimentary Canal*—Because of its mechanical action it is a good tooth powder."[28] Combined with wartime bread it may well be credited with a detergent action on the enamel keeping the surface polished and creamy white in color. Whether it helps, in some cases, to induce hypercalcification under the surface of the enamel by exposing it to the protective salts in the saliva, that are generated exogenously, or whether it induces hypercalcification via the dental fibres it is difficult to say. One thing may well be granted, namely: foods which demand mastication together with a powder which is gritty though not disagreeably so, are cleansing and the slight wearing away of the masticating surface tends to polish the enamel. Moreover, if the enamel is saturated with acid formed by microorganisms lodging unduly long in retention areas there may be a hypercalcification of the dentinal sheaths and the vital fibrils, so that they may become calcified and die or at least cease to undergo metabolic changes such as living protoplasmic substances do. Possibly also this hypercalcification might be accelerated by the administration of cod-liver oil or so called vitamin D which, however, can hardly be called a vitamin, as its equivalent, irradiated ergosterol, is synthesized by the animal body under the outer layer of the skin.

It may be remembered that "Vitamins have one important property in common in that only vegetable life can synthesize them."[29] However, "the fact that the administration of cod-liver oil is by no means an invariably safe proceeding is becoming increasingly clear" (*British Medical Journal*, August 24, 1929). The research work on this subject seems to have been undertaken by Scandinavian investigators in the *Acta Paediatrica*. Even cautious therapeutic doses are explicitly stated to produce distinct changes when the administration is continued for months, and as Dr. Rolf Hallgren points out "most disquieting is the observation that the experimental animals gain weight and appear to be healthy in spite of severe organic lesions, found only at the autopsy" (*Public Health*, February, 1929). And he concludes by saying that "on no account should the doses recommended in current pharmacological textbooks be given during any considerable length of time."

As the action of cod-liver oil "has been studied in a series of different animals—calves, pigs, cats, dogs and rodents—and has been found to be fairly uniform," and as the investigators are apparently of high standing, it would seem wise to call a halt to the wholesale advocacy of cod-liver oil, "vitamin" D, or various forms of irradiated milk.

At a later date Lewis H. F. Thatcher, M.D., F.R.C.P., contributed a paper to the *Edinburgh Medical Journal* 1931 entitled, Hypervitamosis D, with report of a fatal case in a child.

In the April number of *Dental Items of Interest* for 1946 (p. 416) it was said: "The first death of an adult, as a result of Vitamin D intoxication with metastatic calcification, that is the deposition, of calcium in the kidneys, heart, and arteries causing the death is reported by Dr. Bauer. . . In the case reported the total amount of vitamin D consumed appears to be larger than in previous reported children's cases with fatal intoxication. If, however, the dose is calculated in units per kilogram of body weight, it is seen that the dose was rather small and was far below the amount usually considered the toxic level for humans." (Op. Cit., p. 416). Abstracted from *Science News Letter*, October 20th, 1945.

Passing from these grim facts and figures it may be of importance to refer to a correlated but later and more elaborate piece of work in An Investigation into Questions of Social Hygiene in the Countries of Vasterbotten and Norrbotten, Sweden. Conducted with the support of the Royal Medical Board in 1929-1931. The third part of which relates to the Condition of the Teeth and Dental Diseases in Upper Norrland by G. Westin, Chief of the Department of Operative Dentistry of the State Dental College, and H. Holtz and A. Lindstrom, Head-Assistants in the same Department of the College. On page 225 the conclusion is summed up with regard to the relation between the inflammatory changes and simultaneous "rachitic" injuries to the dentine with the words printed in italics "To judge from the histological pictures, in cases of combined caries and rachitic injury to the calcification process, there seems to be no reasons for assuming that the rachitic changes facilitate the onset of caries in any other way than thorough increased retention; it may be expected that in cases with deficient calcification of the dentine the size of the carious cavity that arises is perceptibly increased." On the last page of this erudite and painstaking investigation we read: "There is a distinct connection between the standard of vitamin C and gingivitis. Caries, on the other hand, appears irrespective of the content of vitamin C in the food. These hypoplasias of the enamel of which a lack of vitamin D is one of the causes appear to have no influence in the development of caries. Of course, hypoplastic defects in the enamel do to a certain extent develop into carious injuries, from which it follows that among dentures showing such defects, dentures that are entirely free from caries are less in evidence. As a rule, however, individuals exhibiting signs of early disturbances in the calcification of their teeth are apparently not liable subsequently to suffer from severe caries."[30]

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# Chapter XXIV

## ERRORS, OMISSIONS, RULES AND RESULTS

### *(5th Decade,* 1941-1949)

In a long series of separate communications it would be presumptuous to think that no mistakes, omissions or other unfortunate mishaps had occurred. However, it so happened that after qualifying to practice in medicine I was more or less "hereditarily" constrained to take a special interest in the teeth of civilized man.

Naturally it seemed astonishing to hear of, and see the deplorable state into which the teeth of men, women and children had got, notwithstanding the great progress of medical science and hygiene. Nevertheless to a dental student such as I became nearly sixty years ago, it seemed to indicate that all was not well with regard to our knowledge of the development of the jaws, the regularity of the teeth, or the cause of the prevalence of dental caries and pyorrhea.

We knew that dogs, cats and all Mammalia, in general, had remarkably clean creamy white teeth yet they never brushed them, nor did they use antiseptic mouthwashes and correlated dentifrices. Was it to be wondered at that some dentists could not believe that the advances in medical science, developmental anatomy and alimentary hygiene were altogether satisfactory? No doubt a few distinguished dentists did observe the dilemma into which we had drifted[1] But no one had indicated the way out. Even Miller remarked as I have already noted, "There is no evidence that anything whatever has as yet been accomplished in the prophylactic treatment of the teeth through the use of antiseptic mouthwashes."[2]

The pathology of dental caries and the mode of its attack on the exposed part of the teeth was well elucidated. Indeed the teeth most likely to be attacked and even the particular sites at which caries started, were well known. Unfortunately no one in the dental profession ever suggested a feasible method of prophylaxis though as Miller said "It was evident that anyone who would discover some means by which the often fatal ravages caused by decay of the teeth might be held in check would thereby confer a great boon on humanity."[3]

My studies in biology toward the end of 1890 indicated that the belief in the inheritance of acquired characters and the more popular belief in the degeneracy of the teeth were quite untenable, as I learned and believed in what was taught in my textbooks (1) *Elements of the Comparative Anatomy of Vertebrates*: Adapted from the German of Robert Wiedersheim by W. Newton Parker and (2) *The Physiology of Plants* by Sydney Howard Vines., M.A., D.Sc., F.R.S., (1886).

In our dental textbooks toward the end of the 19th Century and for several years after, we had little or no statistical knowledge of the prevalence of caries at any particular age, but in 1909, W. Baird Grandison began to take records of the number of decayed teeth in children at their sixth year: (That is when they first went to school.) He gave a very remarkable and telltale graph.

Because of this and the unfortunate omission of the explanatory headlines given in Chapter XI of *The Newer Knowledge of Hygiene in Diet*, these may here be given. They read as follows. "Diagram—Showing the percentage of decay in the temporary teeth of the five year group of children from 1909 to 1936."

It will be observed that from 1909, there had, on the whole, been a definite improvement, and a quite remarkable improvement between the year 1917 onwards till 1922. We may presume that the slight improvement between 1909 and 1917 was due to the influence of the newer knowledge of the physiology of oral hygiene together with its influence on the dietetic regime of young children. At any rate the spectacular improvement between 1917 and 1922 is undoubtedly attributable to the restrictions in the consumption of sugar, confectionary, jam and sweets (50 per cent) which were imposed on children during the first world war.[4]

Recently A. T. Wynne, M.B., Ch.B., B.D.S., L.D.S., in the *Ministry of Education* refers to "Wartime Improvement" and makes special note of "The records of the Cambridge Borough school dental service" (which quite rightly he regarded as outstanding) "Here a careful record has been kept of the percentage of decay present in the temporary teeth of the five-year old group of children, since the year 1911,[5] and this is presented in the form of a graph. This shows how the amount of decay in this group of children declined during and after the period of the 1914-18 war, and how, following an increase during the inter-war period, an extraordinarily close parallel with 1914-18 occurred in the recent war" (which commenced in 1939). "The marked reduction in caries makes it difficult wholly to ascribe the similar improvement in the last six years to such factors as priority milk, the supply of cod-liver oil and fruit juices to children and expectant mothers, the vitaminization of margarine and the addition of calcium carbonate to flour, since none of these factors was operative on a national scale during the 1914-18 war. The provision of school meals obviously cannot affect the teeth of school entrants. On the other hand, a reduction of sugar and sweets occurred during both wars and this may be at least one factor in the lessening of dental decay in wartime."[6]

Sir George Newman in his Annual Report on *The Health of the School Child* for the year 1929 says: "There is no evidence of any decrease in the incidence of dental caries among the entrants. On the contrary the reports of some school dentists seem to suggest a deterioration in the condition of the 5-year-old children. In this connection a graph given in the Cambridge Borough report for 1929 is of special interest, as it indicates the percentages of carious temporary teeth in the 5-year-old group of children in the Borough from 1909 to 1929 inclusive. Between 1917 and 1922 the percentage fell steadily from 35 to 12, while from 1922 it has been rising again and now stands at 21. Mr. Grandison makes the following comments: 'This very interesting graph indicating the percentage of decay present in the 5-year-old group of children at inspection, has produced many theories but none more reliable than that connected with the problem of diet during and immediately following the war period. Whether by the blood circulation (internal metabolism) or by direct action on the enamel of teeth, it seems probable that the children who were five years old in 1922 and whose temporary teeth showed decay amounting to only 12.2 per cent, benefited to no small extent by the rationing process, scarcity of sugary foods, etc.' "[7]

Now consider what Grandison's graph shows. Most assuredly it does not give the slightest indication that the structure of the teeth had degenerated between 1909 and 1922. Nor does the graph indicate that any benefit had been derived from giving priority to milk, cod-liver oil and fruit juices to children and expectant mothers, etc., since as Dr. A. T. Wynne has pointed out, none of these factors was operative on a national scale during the 1914-18 war. No doubt, however, the withdrawal of restrictions of the sucking or eating of sweets and the consumption of confectionary accounted for the relatively uniform incidence in caries from 1922 onward when the second world was broke out, and the same restrictions on sweets, sugar, etc., were again imposed. Following this a "spectacular improvement" was recorded in the Annual Report of the School Medical Officer of the Borough of Bury St. Edmunds together with others such as E. Brodin Carpenter gives in a "dramatic picture" of the improvement of the teeth of the children aged 5 to 17 years in an institution which he attends. In 1939, 50 per cent of the children had 0.2 cavities, 32 per cent 3-5 cavities and 18 per cent 6 cavities and upwards. By 1945 a remarkable change had taken place, the saliva from being viscous had become clear, 97 per cent of the children had 0-2 cavities, 3 per cent, 3-5 cavities and there was none in the third category.[8]

Words could not express more satisfactorily the complete untenability of Lady Mellanby's theory of the prevalence of dental caries, while at the same time it corroborates the views which have been given in our standard textbooks since 1910.[9] If, however, more is wanted it can easily be found in a communication to the *British Medical Journal* for October 1946, entitled "Teeth of 5 year-old London School Children by May Mellanby and Helen Coumoulos, Ph.D. Camb., D.D.S. Athens." Here, however, it is hardly necessary to do more than make a few extracts and comments more particularly on those which seem to indicate a belief in the views introduced by Lady Mellanby who gave special attention to the *Structure of Each Deciduous Tooth*:—(Saying) "The standards used were evolved from the results of experiments on animals and investigations made by one of us (Mellanby 1918-34). Individual teeth were taken to be of good structure when their surfaces were smooth, shiny, and white or creamy white in color. Variations from this standard other than gross hypoplasia are referred to as Mellanby—or M—hypoplasia, a term first used by King (1940) to distinguish these types from the gross hypoplasias (G. hypoplasia) which have long been recognized and which are not common in deciduous teeth. The M-type defects were originally described by one of us (Mellanby, 1923, 1927, 1934), who found them in over 80 per cent of the thousands of deciduous teeth examined. Unless the teeth are dried and well illuminated, the defects are not often easily visible to the naked eye, especially when they occur in the molars, but they can be detected without much difficulty when the tooth surfaces are lightly rubbed with a probe. Degrees of roughness are not sharply defined, but merge into one another. With practice—and this must be emphasized—they can, however, be judged by the 'feel' of the probe, and the teeth may be grouped under the following headlines."[10]

I have never had thousands of teeth dried and illuminated. All that seemed necessary to diagnose hypoplasia in the teeth was an illuminated mouth mirror and an ordinary dental probe.

Since 1900 when my first book on the *Cause and Prevention of Decay in Teeth* was published there was a considerable number of dentists and doctors who followed my precepts with most gratifying results,[11] as has already been indicated, but after the misleading word vitamin was introduced in or about 1913 and "struck the imagination of the public," Professor, now Sir Edward Mellanby, and other members of the medical profession championed the fat soluble A or cod-liver oil theory, as naturally Lady Mellanby did in 1918 and year after year onward.

I need not say more about this, suffice it to note that about 1921 the Society of Medical Officers of Health issued a Leaflet for the use of Parents which had been approved of by the Council of the Society. So also was it approved of and reprinted by The Peoples League of Health, (Patron—His Majesty the King) and the Dental Board of Victoria, (Australia). In each of the foregoing the vitamin theory was discarded.

The question here arises: What more can we do about it?

This was revealed in the wartime ration of sweets, jam and confectionary, together with the control in price of herring and other fish which were not rationed and relatively abundant as were potatoes, carrots, turnips, green vegetables, cauliflowers, and in season apples, pears and other fruits of a firm consistency which stimulate mastication. These have all contributed to maintaining oral and alimentary hygiene, and in bringing about a decrease in prevalence of dental caries.

There has been no control by rationing sugar and confectionary in New Zealand, and there the teeth of the children show no "spectacular improvement"; quite the contrary they are said to be "the worst in the world."[12]

Finally, there is no need to spend over £600,000 annually on misleading experiments on children and dogs, which were presumably denied the benefit of ultraviolet light, and sufficient exercise.

That the trend of ideas is now in the right direction is quite noticeable in the book published by the American Dental Association, entitled *Dental Caries.* It was not paid for by taxation, but it gave all who were interested in the subject an opportunity to submit their views, and we know, at least, that they were not biased by hopes of rewards before they were criticized by unbiased authorities who were chiefly concerned about the elucidation of truth.

How erroneous ideas arise or survive after experimental evidence on man has elucidated the truth, may here be briefly illustrated by recalling the fact that in the Second Edition of *A System of Dental Surgery,* John Tomes, F.R.S. and Charles S. Tomes, M.A., in 1873 concluded their pioneer manual by asserting that: "The following conclusions seem to be the most nearly in accordance with the preceding facts, viz: That caries is an effect of external causes, in which so-called 'vital' forces play no part. That it is due to the solvent of acids which have been generated by fermentation going on in the mouth, the buccal mucus probably having no small share in the matter; and when once the disintegrating process is established at some congenitally defective point, the accumulation of food and secretions in the cavity will intensify the mischief by furnishing fresh supplies of acid."

No particular objection need be made to what is said in this quotation, except that it was misleading and unfortunate to have included the words "at some congenitally defective point."

In 1890, the third edition of Henry Sewills' *Dental Surgery* was published. Therein he refers to dental caries and noted that: "Caries often commences on a surface of a tooth perfectly free from inherent structural defect. This occurs especially on lateral aspects or on interstitial surfaces bordering nooks and crannies formed by irregularity and crowding; for it is in these situations, where the shelter allows particles to remain undisturbed for lengthy periods, that organisms and acids are constantly generated during the decomposition of particles of food and irritation of the mucous membrane.

"But caries most frequently has its starting point at some part of the enamel and dentin, the seat of innate structural defect."[13]

Much confusion might have been avoided if "Nature's methods of preserving the enamel" had been observed..

These, it may be recalled, were described as follows: "First, it may be preserved by being kept perfectly free from adherent matter as occurs on the crown surfaces of the teeth of those who eat coarse and non-lodgeable foodstuffs. Secondly, a protective layer of matter which does not become acid in reaction may be deposited on the surface of the enamel and protect it from injury. . . There is reason to believe that its basis is buccal and salivary mucus. This is described as a viscid albuminous material containing albuminous mucus corpuscles frequently mixed with salivary epithelium and *debris.* In the situations where it adheres to the enamel of the teeth, and is not removed during mastication or by the toothbrush, it may be felt by the tongue as a very slightly rough coating. It presents a different feeling to the tongue than does the polished enamel. . ."[14] It is not necessary to reiterate what more was maintained in 1900. Rather would I refer to the views brought forward in 1908 by one of the most celebrated surgeons of the first few decades of the present century. As may well be surmised I refer to Sir Watson Cheyne 1st., Bt., M.P., M.B., F.R.C.S., F.R.S., who gave the Wigham Lecture on "The Defensive Arrangements of the Body as Illustrated by the Incidence of Disease in Children and Adults." (1908).

There he says: "The first line of defense of the body resides, in all probability, in the epithelial tissue which oppose the entrance of infective agents into the body. It clearly must be a local power residing in the epithelial cells themselves, or on the fixed cells on which they are situated, rather than any general condition, such as the presence of poisons in the blood."

It is a somewhat significant fact that the tissues of the mouth are the most resistant to the invasion of micro-organisms. Even a severe injury —e.g., the extraction of a tooth, which may be regarded as a compound fracture is very rarely followed by the invasion of pathogenic micro-organisms beyond the seat of injury. Here we must also note that Sir Watson Cheyne was not referring to the enamel of the teeth over which there are no epithelial cells. Nevertheless the mucus secreted by the mucous membrane and salivary glands furnish liberal suppiies of mucus to cover the exposed surface of the teeth wheresoever it is required to protect the teeth, provided there is adequate mastication of detergent foods.

From the foregoing it may easily be recognized how the M-type defects could be confused with stagnant debris, in such places of the teeth as are not kept clean by mastication of detergent food or the cleansing action of the tongue, cheeks and lips.

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# Index

A

Accepted principles, recapitulation, 176
Acid, lactic, 5
Adenoids, 92
Allen, Irene, 238
Anemia, 92
Appendicitis, 92
Attrition, 227, 228
Author's American tour, 178
Author receives John Tomes prize, 155
Aykroyd's myth, 193
Aykroyd, W. R., 156

B

Bacteria as cleansing agents, 82
  oral, 56
  proteolytic, 8
Bacteriology, history of, 2
Ballast and intestinal peristalsis, 12
Black, G. V., calcium content of teeth, 170
Breast feeding, 99
British diet, 174
Brun, Johan, 233
Bunting, Russell W., 188
  on caries, 205

C

Campbell, Harry, 20
  on hypoplasia, 227
Cancer, 92
Caries, acids in, 21
  and civilization, 30
  and flour dust, 69
  chemical theory, 20
  dental, 4
  dental, and rickets, 186
  dental, and sugar, 11
  dental, and sunshine, 186
  dental, discussion, 48-63
  dental, influence of war conditions, 254
  dental, in South African children, 185
  dental, relative frequency in 10,000 cases, 196
  etiology according to W. D. Miller, 22
  etiology according to Henry Sewill, 23
  etiology according to Sir John and Sir Charles Tomes, 24
  experimental production, 21
  frequency of, 21
  germs in, 21
  immunity of lower anterior teeth, 70
  initial lesion, external, 17
  in South Africa, 52, 53, 55
  methods of prevention, 76
  parasitic theory, 20
  prophylaxis according to W. D. Miller, 24
  relative susceptibility of individual teeth, 71
  relation to sugar, 25
Cellulose, 2, 11, 114
Cleanliness, artificial, 101
  natural, 101
Cod-liver oil, 162
  dangers of, 38
Cohn, 3
Constipation, 31, 82
Cooking, effects of, 103
Cope, E. D., 3

D

Darwin, 3
Debate, summary of author's views, 133
  Wallace's opening remarks, 132
  Wheatley, James, 135
Degeneration, and civilization, 4
  hereditary, 3
Deglutition, 5
Dental caries, and frequency of eating, 66
  increased incidence, 209
Dietetics, modern trends, 112
Diet, and jaw development, 30
  effects of soft, 108
  high fat—low carbohydrate, 221
  hygiene in, 33
  medical system of, 105
  the Sim Wallace, 44, 45

Digestion, 4
  and natural foods, 95
  mechanism of, 5
  principles of, 6
  salivary, 83
Digestive glands, work of, 10
Disease, causation of, 91

E

Eating, family habits, 142
Editorial, *Journal of the British Dental Association,* 136
Ehrenberg, 3
Enzymes, 60
Excerpts from Wallace's American lecture, 178

F

Feeding the child, 109
Fever, relapsing, 92
  typhus, 92
Fermentation, lactic acid, 26
  mannitic or gummy, 5
Ferments, organized and unorganized, 5, 8
Fibrous food benefits, 58
Film, protective, 222
Fish, Eric W., 245
  on attrition, 228
Fones, A. C., 11
Food, acid and teeth, 103
  author's menus, 90, 91
  consistency and peristalsis, 66
  civilized, 14
  factors, accessory, 190
  fibrous, 90
  gnawing, 108
  history of processing, 30
  in wartime, 151
  natural preferences, 78
  nitrogenous, 2
  physical and chemical nature, 9
  starchy, 2
Foodstuffs, accessory, 11
  effects of, 11
  essential, 11
Foster, Sir Michael, 4, 5, 8
Funk, Casmir, and vitamins, 126

G

Gastric insufficiency, 92
Gibbs, J. H., Comments on Causation of dental caries, 99, 100
Gies, William J., Comments on Priority of Wallace, 122
Glucose, 162
Godon, Dr., Comments on Priority of Wallace, 127
Growth and function, 34

H

Heredity, and similarity of environment, 99
  legal, 27
Holborn, F. M., Comments Concerning Sim Wallace, 175
Howe, Percy, 12
  comments, 114
Hrdlicka, Alexis, on functional form, 182, 183
Humphreys, Humphrey, F., 209
Hutchison, Sir Robert, 12
Huxley, 9
Hygiene, 1
  alimentary, 7, 16
  alimentary and function, 10
  dental, in infancy and childhood, 132
  in diet, 230
  intestinal, 231
  oral, 9
Hypoplasia, 224

I

Immunity, 142
Indigestion, 92
Infantile diarrhea, 92
Inheritance, legal, 211
Insanity, 92
Intoxication, vitamin D, 250

J

Jaws, development of, 30
  mechanics of, 88
Juices, gastric, 4

K

King, Sir Truby, Comments on Priority of Wallace, 124
Kircher, 2
Klatsky, Meyer, on attrition, 228, 229

L

Lactose, 162
Lamarck, 3
*Lancet,* on "The Problem of Dental Disease", 139
Leaflet for use of Parents, 152
Lindsay, Lilian, 27
  A Short History of Dentistry, 201
  on prevention of Dental Caries, 143
Linnaeus, 3
Leeuwenhock, 2

M

Macphee, G. Graham, on dental caries, 162
Magendie, report on white bread, 156

- Magitot, 19
- Malocclusion, and mastication, 67
  - etiology, 36
- Mannite fermentation, 26
- Mastication, 9
  - and food refinement, 93
  - benefits of, 91
  - mechanism of, 67
  - process, 58
  - self cleansing action, 65
- Meals, method of arrangement, 110
- Menus, author's, 79
- Medical fallacies, 104
- *Medical Press,* comments re Sim Wallace, 97
- Mellanby, May, 154
  - report and author's comments, 158
- Micro-organisms of the mouth, 68
- Miller, W. D., 20
  - antiseptics in control of dental caries, 138
- Milk, 78
- Mouth breathing, 87
- Mouth, glands of, 7
- Mouth washes, antiseptic, 40
- Mucus, 8, 62
  - protective properties, 80
  - secretion in relation to food, 68
- Mummery, J. H., 41
  - comments, 127

**Mc**

- McCulloch vs. Mellanby, 203
- McCollum, diet in relation to teeth, 217

**N**

- Neurasthenia, 92
- Newman, Sir George, Annual Report, 155

**O**

- Oral hygiene, failure of, 149
- Osler, Sir William, quotation on hygiene, 173
- Oslo Breakfast, 233
- Overeating, 111

**P**

- Pap feeding, and mannitic fermentation, 14
  - sugar in, 13, 14
- Parmly, L. S., 16
- Pasteur, Louis, 3
- Perceptions, tactile, 8
- Physiology of oral hygiene, 152
- Pickerill, H. P., on prevention of dental caries, 121
- Pitts, A. T., comments, 128
- Plenciz, 3
- Price, Weston A., 187
- Proteids, 84
- Ptyalin, 8
  - function of, 5

**R**

- Rabies, 92
- Research, controlled, 185
- Residue, indigestible, 82
- Rickets, 38, 92
- Robertson, William, 17
- Rowlett, A. E., on prevention of dental caries, 188

**S**

- Saliva, afterflow, 89
  - in digestion, 5
- Salivary glands and hygiene, 61
- Salts, 84
- Schioitz, Carl, 240
- Scotland, Isles of, 49
- Scurvy, 1
- Selection, natural, 3
- Sewill, Henry, 19
- Shaw, J. C. Middleton, 186
- Sherman, Henry C., on hygiene in diet, 212, 230
- Smallpox, 92
- Starch, conversion of, 9
- Starr, Oran, 4
- Sucrose, 162
  - and mannitic fermentation, 200
- Sugar, effect of refinement, 83
  - pathological craving, 110
- Sunshine in England and Johannesburg, 163
- Susceptibility, 142
- Swallowing, 9
- Sweets, wartime restriction of, 256
- Symbiosis, 11

**T**

- Taste, 9
- Teeth, 4
  - and degeneration, 94
  - children's, 106
  - diseases of, 30
  - eruption, 35
  - eruption and food, 60
  - in Bantu races, 186
  - irregularities of, 33, 72
  - of physicians' children, 106
  - prevention of irregularities, 86
  - relative tendency to decay, 20
  - wear of cusps, 65
- Theories, dietetic, 63, 64, 65
- Tongue, action of, 9
  - size in relation to jaws, 88
- Tomes, Sir John and Sir Charles, 17
- Toothbrush, cosmetic value of, 74

    dangers of, 73
    effects of use of, 80
Tract, digestive, 10
Tristan da Cunha, 165

U

Underwood, 20

V

Variation, 3
Vitamin D, 162
Vitamins, curative influence of, 1
    history of, 1

W

Wallace, A. R., 3
Wallace's physiological regime, 41, 42, 43, 44
Weaning and supplemental foods, 85
Wheatley, James, comments on dental caries, 116, 117
Wiedersheim, Prof. Robert, 7, 8

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